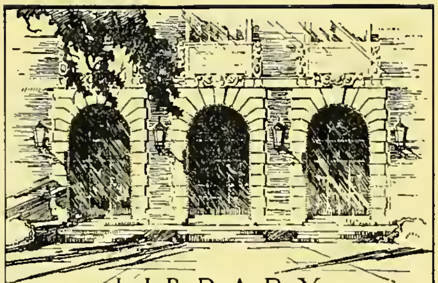

170

INTRODUCTION TO HUMAN ECOLOGY

(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369).

Preliminary Edition, Revised September, 1964

Course Guide
to
Introduction to Human Ecology
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369.)

Teaching Staff

Alfred W. Booth, Professor of Geography (223 Davenport; X-3-3006).

Jerome D. Fellmann, Professor of Geography (122 Davenport; X-3-3135)

Kenneth E. Harshbarger, Professor of Nutrition, Dairy Science Dept.; Assoc. Head of Dept. (315 An. Sci. Lab.; X-3-1836).

Alan H. Jacobs, Instructor in Anthropology (137g Davenport X-3-1313)

S. Charles Kendeigh,* Professor of Zoology (200 Vivarium; X-3-1632).

Norman D. Levine,* Professor of Veterinary Parasitology and of Veterinary Research (143 Vet. Med.; X-3-2766, X-3-1937).

Lawrence I. O'Kelly, Professor of Psychology (129 N. Race St., Urbana; X-3-3483).

Morell B. Russell, Professor of Soil Physics; Assoc. Director, Agric. Expt. Station (109 Mumford; X-3-0240).

Frederick Sargent, II,* Professor of Physiology (31 Burrill; X-3-3002). Acting Course Administrator

Demitri B. Shimkin,* Professor of Anthropology and of Geography. Course Administrator. On leave of absence.

Robert W. Touchberry, Professor of Genetics, Dairy Science Dept.; (215e An. Sci. Lab.; X-3-2627).

Leigh M. Triandis, Assistant Professor of Psychology (433a Gregory; X-3-2769).

Robert C. White, Map and Geography Librarian (418b Library; X-3-0827). Course Librarian.

Betty W. Starr, Secretary, Department of Anthropology and of the University Committee on Human Ecology. (137c Davenport; X-3-3616).

* Senior Staff Member, Center for Zoonoses Research.

September, 1964

I. Objectives, Organization and Procedures.

1. "Introduction to Human Ecology" seeks to give advanced undergraduate and graduate students in the biological and social sciences, including regional planning and other areas of application, a working knowledge of principles, techniques and findings useful for the study of the relations between human populations and their environments. Because human ecology is a specialized aspect of the general adaptation of living organisms to their environment, the first part of the course undertakes a brief but intensive review of ecology as a whole. Beginning with an analysis of environments, it then surveys physiological requirements, life cycles and regulatory mechanisms in animals as a foundation for understanding biological communities. The second part of the course deals with the biological and cultural aspects of human adaptation. It stresses man's neuropsychological specializations and their consequences. It reviews, type by type, the expansion of human productive capacities and of human societies, from hunting and gathering to modern industrial societies. Finally, the course focuses on problems of application: the ecology of health, and the use of ecological principles in regional planning.

2. Throughout the course, emphasis will be placed upon elements, relations and processes unifying animal and human ecology, on one hand; and on the mechanisms and consequences of biological and cultural evolution, on the other. Quantitative measures and models will be used as guides, but will not be extensively developed. Ample references to the basic literature pertinent to ecology will give students means to extend their knowledge during the course and subsequently.

3. Pedagogically, the course represents a compromise between the needs for highly specialized competences and the unification gained through a single mind. The staff will present lectures in series of at least a week's duration.* The course administrator will be present at all lectures, in order to maximize continuity. In addition, every student will be assigned to a staff member for guidance in his semester paper and for periodic consultations.

4. The course requirements will include careful grasp of the lectures and required reading, which will be verified by one mid-semester examination and the final examination; preparation of a 5,000-10,000 word paper based on use of the reference data and suggested readings, and demonstrating a serious exploration of one aspect of human ecology; and participation in classroom discussions. Approximately one-quarter of the grade will be derived from the student's paper. However, the overall grade will depend on the intuitive judgment of the staff in each case. With the expected maturity and quality of the students, the probable median should exceed "B".

---

*Brief summaries of the salient points of each group of lectures accompanied by references to required and optional readings will be distributed to the students periodically.

I. Objectives, Organization and Procedure.

1. This course is designed to [illegible] advanced undergraduate and graduate students [illegible] interest and social relevance [illegible] planning, and other areas [illegible], a [illegible] findings useful for the study of the relations between human populations and their environments. Because human ecology is [illegible] aspect of the general relationship of living organisms to their environment, the first part of the course [illegible] a brief but intensive review of ecology as a whole. [illegible] analysis of environments, [illegible] regulatory mechanisms [illegible] foundation for understanding [illegible] ecological communities. The second part of the course deals with the biological and cultural aspects of human adaptation. It [illegible] specializations and their consequences. [illegible] the expansion of human productive capacity [illegible] from hunting and gathering to modern industrial societies. Finally, the course focuses on problems of [illegible], the ecology of health, and the use of ecological principles in regional planning.

2. Throughout the course, emphasis will be [illegible] and principles [illegible] and human ecology, [illegible] and [illegible] of life [illegible] and cultural evolution, [illegible]. Quantitative [illegible] will be used as guides, but will not be [illegible]. [illegible] to extend their knowledge [illegible] theory and concepts.

3. [illegible], the course represents a compromise between the needs [illegible] and the [illegible] single [illegible]. The [illegible] series of [illegible] the course [illegible] will [illegible].

4. The course requirements will [illegible] of the [illegible] which will be [illegible] and the final [illegible] paper [illegible] the [illegible] of [illegible]. [illegible] of the grade will be [illegible] the [illegible] will [illegible] of [illegible] each [illegible] should [illegible].

[illegible]

5. The basic reference data for the course (see bibliography), as well as the specifically assigned readings for each group of lectures will be on reserve at the Map and Geography Library (418b Library). Furthermore, Mr. White will attempt to locate, so far as feasible, the other copies which may be available elsewhere in the University, and to make this information accessible to students. Students unfamiliar with the concepts of human ecology will find Marsten Bates' Man in Nature to be a lucid, readable elementary survey.

6. At the level of 3 hours, or a half-unit of graduate credit, the semester paper will serve fundamentally as an integrating device for each student's understanding of the principles of ecology as applied to a given topic. It is expected that the required readings, the basic reference data, and supplementary suggestions by individual lecturers will provide ample substantive bases for the paper. Added research is neither expected nor encouraged at this stage; problem formulation, the selection of pertinent evidence, and logical analysis are the objectives. For added credit, indpeendent investigations of some depth will be required.

II. Schedule of Lectures and Mid-term Examination.

Date	Lect.	Title	Lecturer
Sept. 21	1	The nature of human ecology	Sargent
Sept. 23	2	The earth's environment as a physico-chemical system	Geog.Staff
Sept. 25	3	The evolution of terrestrial environments	Geog.Staff
Sept. 28	4	Contemporary environments (biomes)	Geog.Staff
Sept. 30	5	Physiological and morphological mechanisms in homestasis	Sargent
Oct. 2	6	Processes of growth, maturation and aging	Sargent
Oct. 5	7	Reproduction and fertility in mammalian populations	Sargent
Oct. 7	8	Organic control mechanisms: genetics as cybernetics	O'Kelly
Oct. 9	9	Organic control mechanisms: basic processes of external regulation	O'Kelly
Oct. 12	10	Organic control mechanisms: integration and control in higher animals	O'Kelly
Oct. 14	11	The biotic community as a concept	Kendeigh
Oct. 16	12	Successions, climaxes and biomes	Kendeigh
Oct. 19	13	Speciation, adaptation, dispersal and the ecological niche	Kendeigh
Oct. 21	14	Nutrient cycles, food chains, and population dynamics	Kendeigh
Oct. 23	15	Energy flows and biological productivity	Kendeigh
Oct. 26	16	The evolution of Homo sapiens	Sargent
Oct. 28	17	General biological characteristics of Homo sapiens	Sargent

Oct. 30	18	The psychoneurological specializations of man	Sargent
Nov. 2	19	MID-TERM EXAMINATION	
Nov. 4	20	The mechanisms and institutions of human socialization	Anthro.Staff
Nov. 6	21	Patterns of human utilization of the natural environment	Anthro.Staff
Nov. 9	22 & 23	Processes of socio-cultural evolution Stages of socio-cultural evolution	Anthro.Staff
Nov. 11	24	Evolution of the food quest	Anthro.Staff
Nov. 13	25	Agricultural Ecology--The Climatic Factor	Booth
Nov. 16	26	The Nature, Properties and Geographic Distribution of Soils	Russell
Nov. 18	27	The Soil as a Medium for Plant Growth	Russell
Nov. 20	28	Agricultural Ecology-Tropical Subsistence Agriculture	Booth
Nov. 23	29	Agricultural Ecology--Agriculture of the Indian Subcontinent	Booth
Nov. 25	30	Agricultural Ecology--The European Peasant Economy	Booth
VACATION - Nov. 25, 1 p.m. - Nov. 30, 1 p.m.			
Dec. 2	31	Commercialized agriculture	Russell
Dec. 4	32	The Nature, Mechanisms and Consequences of Changes in Human Populations	Sargent
Dec. 7	33	The Nature of Cities and the Rise of Urbanism	Fellmann
Dec. 9	34	The Pre-industrial City: Western Europe	Fellmann
Dec. 11	35	The Industrial City and External Urban Relationships	Fellmann
Dec. 14	36	The Classical City of the Industrial Era	Fellmann

Dec. 16	37	The Emergent Urban Community	Fellmann
Dec. 18	38	Applied human ecology: principles of epidemiology	Levine
Dec. 21	39	Applied human ecology: malaria and other insect-borne diseases	Levine

VACATION - Dec. 22, 1 p.m. - Jan. 4, 1 p.m.

Jan. 6	40	Applied human ecology: new frontiers in epidemiology	Levine
Jan. 8 & Jan. 11	41 & 42	Changing animal populations to supply human needs.	Touchberry
Jan. 13	43	Applied human ecology: Food population interactions	Harshbarger
Jan. 15	44	Concluding remarks: Emphases and limitations of the course; further perspectives in human ecology	Sargent
Jan. 26		FINAL EXAMINATION 8:00 - 11:00	Staff

III. Basic Reference Data

The extensive scope of human ecology and the variety of pertinent substantive data necessitate the use of a considerable body of reference materials, even at an introductory level. The sources cited below represent materials with which every serious student of human ecology should be familiar, and it is expected that all students will browse through this literature. In addition, selected portions will be assigned as required readings in support of particular groups of lectures, or individual lectures. These materials, plus a limited number of suggestions offered in connection with individual lectures, should provide ample data for the student papers.

In order to facilitate the use of these volumes, each has been annotated with suggestions as to its significance for human ecology. Also, a guide to particularly important chapters of the monumental <u>History of Technology</u> has been provided below.

1. Bates, M.: <u>Man in Nature</u>. Prentice-Hall, Inc. Englewood Cliffs, N. J., 1961. pp. 116.

A broad yet simple treatment of the field of human ecology by an outstanding authority on the tropics. Highly recommended to all students for initial orientation.

2. Theodorson, Geo. A. (ed.): <u>Students in Human Ecology</u>. Row, Peterson & Co. Evanston, 1961. pp. 628.

A somewhat more advanced treatment which comprises a selection of essays on concepts and methods in human ecology.

3. Blum, H. F.: <u>Time's Arrow and Evolution</u>. 1st Edition (1951) or 2d Edition (1955). Princeton Univ. Press. Princeton, N. J. pp. 220.

A brilliant analysis of the origin and evolution of life from a physico-chemical standpoint, with particular reference to biological implications of the second law of thermo-dynamics (conservation of energy). Although a difficult work in parts, it represents an indispensible part of the theoretical structure of modern ecology.

4. von Bertalanffy, L.: <u>The Problems of Life: An Evaluation of Modern Biological and Scientific Thought</u>. Harper Torch Books TB-521. 1960. pp. 216.

Also of great theoretical importance, particularly in advancing the concepts of "open systems" and "steady states" to clarify the apparent anomalies between biological (also, socio-cultural) systems and the second law of thermo-dynamics. The thesis is lucidly presented so that the intelligent reader with some biological background can grasp the broad significance of this new viewpoint.

5. von Neumann, J.: The Computer and the Brain. Yale University Press, New Haven, Conn. pp. 82.

A work of extraordinary brilliance which analyses the characteristics of human neurological behavior as a radically different system from that of mechanical computers. The findings of this study have basic applicability to all organic control systems. This work, although profound, can be understood by readers with limited mathematical background.

6. Huxley, Julian.: Evolution in Action. Harper, New York. 1953. pp. 182.

This short essay was taken from a series of popular lectures given a few years ago at the University of Indiana. Professor Huxley, grandson of Darwin's "bulldog", the redoubtable Thomas Huxley, is one of the world's leading authorities of evolutionary biology, and "Evolution in Action" is a carefully weighed statement of contemporary evolutionary theory.

7. Dobzhansky, Th. Evolution, Genetics and Man. Wiley, New York. 1955. pp. 398.

Professor Dobzhansky, of Columbia University, is a leading student of genetic mechanisms in evolution, and is a talented literary expositor of his subject. Of greatest importance to the student of human ecology is Dobzhansky's concept of the "gene pool", basic to an understanding of the statistical reasoning that supports a great deal of evolutionary theory.

8. Kendeigh, S. C.: Animal Ecology. Prentice-Hall. Englewood Cliffs, N. J. 1961. pp. 468.

A comprehensive treatment of the entire field of animal ecology from the structural, regional and historical viewpoints. Carefully organized for ease of use, the work summarizes basic findings, presents critical measures, succinctly discusses case materials, and cities major relevant sources. The theoretical treatment of the biological community is particularly outstanding.

9. Kroeber, A. L.: Cultural and Natural Areas of Native North America. Univ. of Calif. Press, Berkeley. 1939. pp. 242.

This is the classical ecological interpretation of a major world region. It analyzes the relation of population densities and cultural growth to environmental and historical factors. Although some of the content is outdated, the conceptual treatment has been a landmark in human ecology.

10. Driver, H. E. and W. Massey: Comparative Studies of North American Indians. Trans. Amer. Philosophical Soc. vol. 47, pt. 2, 1957, pp. 456.

A basic complement to Kroeber's study, this deeply insightful monograph details the contents of the major cultures of native North America. Then it undertakes quantitative investigations of great theoretical importance to test the validity of ecological interpretations of social structure.

11. Thompson, W. S. Population and Progress in the Far East. Univ. of Chicago Press, Chicago, 1959. pp. 444.

A judicious survey of the population trends, resources, and economic development of the major Asiatic nations. It provides a valuable foundation for more intensive ecological studies of each country, and for comparisons with other areas.

12. Kiser, C. V. and F. Boudreau: Population Trends in Eastern Europe, the USSR and Mainland China. Milbank Memorial Fund, New York, 1960. pp. 336.

This volume summarizes present-day knowledge of population dynamics, determinants and controls in Eastern Europe and the USSR. These represent major components of the ecological systems of industrializing countries, modified structurally by the effects of World War II and the consequences of totalitarian regimes. The detailed information on the vast uncertainties of Chinese population data provides cautions applicable to the demographic "statistics" of most under-developed countries.

13. Freedman, Whelpton, and A. A. Campbell. Family Planning, Sterility and Population Growth. 1960.

The demography of voluntary fertility as practiced in the United States.

14. Singer, C., et al. History of Technology. 5 vols., Oxford Univ. Press, London, 1954-58.

The indispensable source for the study of the development of material culture and economic organization in the western world. The treatments of Eastern Europe and Russia are seriously inadequate. Note that even this tremendous undertaking fails to encompass non-western developments.

Salient chapters include the following:

vol. I From Early Times to Fall of Ancient Empires. London: Oxford, 1954.

pp. 1-37. Oakley, K. P.: "Skill as a human possession."

pp. 38-57. Childe, V. G.: "Early forms of society."

pp. 58-84.. Harrison, H. S.: "Discovery, invention and diffusion."

pp. 154-186. Forde, D.: "Foraging, hunting and fishing."

pp. 327-352. Zeuner, F. E.: "Domestication of animals."

pp. 353-375. Zeuner, F. E.: "Cultivation of plants."

pp. 520-557. Drower, M. S. "Water-supply, irrigation and agriculture."

pp. 744-773. Hooke, S. H.: "Recording and writing."

vol. II. The Mediterranean Civilizations and the Middle Ages. London: Oxford, 1956.

pp. 1-41. Bromehead, C. N.: "Mining and quarrying to the seventeenth century."

pp. 493-536. Goodchild, R. G.: "Roads and land travel," with a section on harbours, docks and lighthouses.

pp. 629-657. Gille, B. Machines.

pp. 753-776. Singer, C. "East and West in retrospect."

vol. III. From the Renaissance to the Industrial Revolution, c. 1500-c. 1750.

pp. 27-71. Smith, C. S. and R. J. Forbes: "Metallurgy and assaying."

pp. 110-133. Salamon, R. A.: "Tradesmen's tools, c. 1500-c. 1850."

pp. 269-299. Briggs, M. S.: "Town-planning from the ancient world to the Renaissance."

pp. 620-647. Price, D. J.: "The manufacture of scientific instruments from c. 1500 to c. 1700."

pp. 709-722. Hall, A. R.: "The rise of the west."

vol. IV. The Industrial Revolution. London: Oxford, 1958.

pp. 1-12. Beaumont, O. and J. W. Y. Higgs: "Agriculture. Farm Implements."

pp. 13-43. Fussell, G. E.: "Agriculture. Techniques of farming."

pp. 149-167. Forbes, R. J.: "Power to 1850."

pp. 230-257. Clow, A. and N. L.: "The chemical industry: interaction with the industrial revolution."

pp. 489-503. Kennard, J.: "Sanitary engineering: water supply."

pp. 504-519. Rawlinson, J.: Sanitary engineering: Sanitation."

pp. 603-682. Ubbelohde, A.R.J.P.: "The beginning of the change from craft mystery to science as a basis for technology."

vol. V. The Late Nineteenth Century. London: Oxford, 1958.

pp. 1-25. Fussell, G. E.: "The growth of food production."

pp. 26-52. Morris, T. N.: "Management and preservation of food."

pp. 208-234. Jarvis, C. M.: "The distribution and utilization of electricity. electricity."

pp. 322-349. Ellis, C. Hamilton: "The development of railway engineering."

pp. 636-657. Galloway, D. F.: "Machine-tools."

pp. 799-813. Wilson, C. "Technology and industrial organization."

pp. 814-842. Fleek, A. "Technology and its social consequences."

vol. IV. The Industrial Revolution. London: Oxford, 1958.

pp. 1-12. Beaumont, O. and J. W. Y. Higgs: "Agriculture. Farm Implements."

pp. 13-43. Fussell, G. E.: "Agriculture. Techniques of farming."

pp. 149-167. Forbes, R. J.: "Power to 1850."

pp. 230-257. Clow, A. and N. L.: "The chemical industry: interaction with the industrial revolution."

pp. 489-503. Kennard, J.: "Sanitary engineering: water supply."

pp. 504-519. Rawlinson, J.: Sanitary engineering: Sanitation."

pp. 603-682. Ubbelohde, A.R.J.P.: "The beginning of the change from craft mystery to science as a basis for technology."

vol. V. The Late Nineteenth Century. London: Oxford, 1958.

pp. 1-25. Fussell, G. E.: "The growth of food production."

pp. 26-52. Morris, T. N.: "Management and preservation of food."

pp. 208-234. Jarvis, C. M.: "The distribution and utilization of electricity. electricity."

pp. 322-349. Ellis, C. Hamilton: "The development of railway engineering."

pp. 636-657. Galloway, D. F.: "Machine-tools."

pp. 799-813. Wilson, C. "Technology and industrial organization."

pp. 814-842. Fleek, A. "Technology and its social consequences."

INTRODUCTION TO HUMAN ECOLOGY

LIST A

BASIC REFERENCE DATA

572 B31m	Bates, M. Man in nature. (Copies also in Biology, Commerce, Physical Education, Undergraduate)
570 B46bE 1960	Bertalanffy, L. von. Problems of life. (Copies also in Biology, Stacks)
575 B62t	Blum, H. F. Time's arrow and evolution. (Copy also in Engineering)
575 D65e	Dobzhansky, T. G. Evolution, genetics and man. (Copy also in Agriculture)
Uncat	Driver, H. E. Comparative studies of North American Indians.
506 APT n.s. v. 47	Driver, H. E. Comparative studies of North American Indians. (IN American Philosophical Society Transactions. v. 47, pt. 2. (Stacks)
612.63 F87f	Freedman, R., et.al. Family planning, sterility and population growth. (Copies also in Agriculture, Commerce)
301 H31h	Hawley, A. H. Human ecology. (Copies also in City Planning, Commerce)
575 H982ev	Huxley, J. Evolution in action. (Copy also in Undergraduate)
591.5 K34a	Kendeigh, S. C. Animal ecology. (Copies also in Biology, Natural History Survey, Veterinary Medicine)
572.97 K91c	Kroeber, A. L. Cultural and natural areas of native North America.
913.05 CA v. 38	Kroeber, A. L. Cultural and natural areas of native North America. IN University of California publications in American archaeology and ethnology. (Stacks)
614 M59p 1959 pt. 1	Milbank memorial fund. Proceedings... 1959. Population trends in Eastern Europe, the USSR and Mainland China. (Copies also in Commerce, Stacks)
609 Si6h	Singer, C., et.al. History of technology. 5 vols. (Copies also in Engineering, Reference; Architecture vols. 4 & 5 only)

301.308 T34s Theodorson, G. A., ed. Studies in human ecology.
(Copies also in City Planning, Commerce, Veterinary Medicine)

330.95 T37p Thompson, W. P. Population and progress in the Far East.
(Copy also in Commerce)

510.84 V89c Von Neumann, J. The computer and the brain.
(Copies also in Engineering, Labor and Industrial Relations, Mathematics, Physics, and Undergraduate)

INTRODUCTION TO HUMAN ECOLOGY

LIST B

OTHER REFERENCES

612.591 Adolph, E. F. Physiology of man in the desert.
Ad7p (Biology)

612 Adolph, E. F. Physiological regulations.
Ad7p (Biology)

572.05 American anthropologist.
AM (Commerce, 1952-date; Stacks, 1899-1951)
n.s.

610.5 American journal of tropical medicine and hygiene.
AMTR (Biology)

371.8505 American Scientist.
SX (Biology, Chemistry, Mathematics, Stacks)

910.6 Association of American Geographers. Annals.
AS (MAP AND GEOGRAPHY)

301 Barnett, H. G. Innovation: the basis of cultural change.
B26i (Commerce)

152.8 Bartley, S. H. Principles of perception.
B28p (Education)

276.2 Bell, H. I. Cults and creeds in Graeco-Roman Egypt.
B41c (Stacks)

581.19 Bonner, J. F. Plant biochemistry.
B64p (Agriculture, Biology, Chemistry)

333.7 Brown, H. S., et al. Next hundred years.
B812n (Commerce, MAP AND GEOGRAPHY, Reference, Undergraduate, Union Browsing)

913.05 Anthropological records.
CAL (Stacks)

612 Cannon, W. B. Wisdom of the body.
C16w2 (Biology, Commerce, Engineering, Physical Education, Stacks, Undergraduate)

338.1 Clark, F. L., and Pirie, N. W. Four thousand million mouths.
C547f (Agriculture, Stacks)

599.8 Clark, W. E. LeG. Antecedents of man.
C54a (Biology, Commerce, Natural History Survey)

915 C86a 1951 — Cressey, G. B. Asia's lands and people.
(MAP AND GEOGRAPHY)

799.296894 D24W — Darling, F. F. Wild life in an African territory.
(Biology, Veterinary Medicine)

546.2 D29w — Davis, K. S., and Day, J. A. Water, the mirror of science.
(Engineering, Undergraduate)

575.1 D65b — Dobzhansky, T. Biological basis of human freedom.
(Biology, Education, Journalism)

616 D78s — Drake, Daniel. A systematic treatise, historical, etiological, and practical, on the principal diseases of the interior valley of North America, as they appear in the Caucasian, African, Indian, and Esquimaux varieties of its population.
(Stacks)

330.5 ECDE — Economic development and cultural change.
(Commerce, City Planning, MAP AND GEOGRAPHY)

616.805 EL — Electroencephalography and clinical neuro-physiology.
(Biology)

572.05 FA — Fieldiana, anthropology. (Field Museum of Natural History. Publications. Anthropological series XV)
(Stacks)

551 F49p 1957 — Finch, V. C., et al. Physical elements of geography.
(MAP AND GEOGRAPHY, Stacks, Undergraduate)

910.5 GEOR — Geographical review.
(Agriculture, MAP AND GEOGRAPHY; Stacks, v. 1-34 only)

550.6 GE — Geological Society of America. Bulletin.
(Geology)

330.9 G43a — Ginsburg, N. S. Atlas of economic development.
(Agriculture, Commerce, Labor and Industrial Relations, MAP AND GEOGRAPHY, Undergraduate)

915 G43p — Ginsburg, N. S., ed. Pattern of Asia.
(MAP AND GEOGRAPHY, Undergraduate)

575.3 H34f 1958 — Henderson, L. J. Fitness of the environment.
(City Planning)

914 H672g 1961 — Hoffman, G. W. A geography of Europe, including Asiatic USSR.
(MAP AND GEOGRAPHY)

570.5 HU — Human Biology.
(Biology, Agriculture)

570.5 ILL — Illinois University. Illinois biological monographs.
(Biology, Natural History Survey, Stacks)

612.67 In7b — Institute of Biology. Biology of ageing.
(Biology, Veterinary Medicine)

573.4 In8m — International Symposium on Man's Role in Changing the Face of the Earth. Man's role in changing the face of the earth.
(City Planning, Engineering, Labor and Industrial Relations, MAP AND GEOGRAPHY)

507 K13p — Kansas University Museum of Natural History. Publications.
(Biology, Natural History Survey)

631 K29s — Kellogg, C. S. Soils that support us.
(Agriculture, City Planning, MAP AND GEOGRAPHY, Natural History Survey)

633 K66e — Klages, K. H. W. Ecological crop geography.
(Agriculture, Biology, MAP AND GEOGRAPHY, Natural History Survey)

612.8217 K67sl — Kleitman, N. Sleep and wakefulness.
(Biology)

612.82 L33h — Lassek, A. M. Human brain.
(Biology)

330.9 L51c — Lee, D. H. K. Climate and economic development in the tropics.
(Biology, Commerce, MAP AND GEOGRAPHY, Veterinary Medicine)

q591.69 L578p — Levine, N. D. Protozoan parasites of domestic animals and of man.
(Biology, Veterinary Medicine)

392.5 L57s — Levi-Straus, Claude. Structures elementaires de la parante.
(Commerce)

321.8 L668p — Lipset, S. M. Political man.
(Commerce, History, Journalism, Labor and Industrial Relations, MAP AND GEOGRAPHY, Undergraduate)

631 L98n 1960 — Lyon, T. L., et al. Nature and properties of soils.
(Agriculture, City Planning, earlier editions in other locations)

614.53 M14m — Macdonald, G. Epidemiology and control of malaria.
(Biology, Veterinary Medicine)

614.42 M45e — May, J. M. Ecology of human disease.
(Physical Education)

575.1 M46f — Medawar, P. B. Future of man.
(Biology, Commerce, Undergraduate, Veterinary Medicine)

612.6 N14r — Nalbandov, A. V. Reproductive physiology; comparative reproductive physiology of domestic animals, laboratory animals and man.
(Agriculture, Biology, MAP AND GEOGRAPHY, Veterinary Medicine)

506 NEW — New York Academy of Sciences. Annals.
(Biology, Stacks)

Uncat — Nobach, C. R. Heritage of the human brain.
(MAP AND GEOGRAPHY)

612.82 N66h — Nobach, C. R. Heritage of the human brain.
(Biology)

333.7 P369p. — Pelzer, K. J. Pioneer settlement in the Asiatic tropics.
(Agriculture, Commerce, MAP AND GEOGRAPHY)

612.82 P42h — Pfeiffer, J. Human brain.
(Biology, Undergraduate)

612.05 PHR — Physiological reviews.
(Agriculture, Biology, Chemistry, Home Economics)

150.5 PRB — Physchological bulletin.
(Education 1952 +, Stacks 1904-1951)

330.9 P98e — Putnam, P. C. Energy in the future.
(Engineering, Stacks)

570.5 QU — Quarterly review of biology.
(Agriculture 1946 +
Biology 1951 +
Natural History Survey 1951 +
Stacks 1936-1950)

338.27 R31e — Resources for the Future. Energy in the American economy, 1850-1975.
(Commerce, Geological Survey, MAP AND GEOGRAPHY)

136.08 R62b — Roe, A., and Simpson, G. G., eds. Behavior and Evolution.
(Biology, Education, Natural History Survey)

566 R66v 1945 — Romer, A. S. Vertebrate paleontology.
(Biology, Geology, Undergraduate)

Uncat — Scholander, P. F. Evolution of climatic adaptation in homeotherms.
(MAP AND GEOGRAPHY)

575.05 EVO — Scholander, P. F. Evolution of climatic adaptation in homeotherms. In Evolution, v. 9.
(Biology, Natural History Survey)

505 SJ — Science.
(Agriculture 1905 +
Biology 1883 +
Chemistry 1940 +
Engineering 1930 +
Geology 1956 +
Home Economics 1928 +
Mathematics 1901 +
Natural History Survey 1883 +
Physics 1952 +
Reference 1952 +
Stacks 1883-1951 +
Undergraduate 1952 +
Veterinary Medicine 1895 +)

605 SA — Scientific American.
(Agriculture 1948 +, Biology 1958 +, Engineering 1959 +, Geology July 1959 +, Law 1956 +, Library School, current, Mathematics 1956 +, Reference Room 1959 +, Stacks 1952 +, Veterinary Medicine 1961 +)

Uncat — Scrimshaw, N. S., and Behar, M. Protein malnutrition in young children. From Science 133: 2039-2047.
(MAP AND GEOGRAPHY)

561 Se8p — Seward, A. C. Plant life through the ages.
(Geology, Stacks)

384 Sh19m — Shannon, C. E. Mathematical theory of communication.
(Education, Engineering, Journalism, Library School, Mathematics, Music, Physics)

573.6 Sh2m — Shapiro, H. L. Migration and environment.
(Biology, Stacks)

575 Si5m 1950 — Simpson, G. G. Meaning of evolution.
(Biology, Commerce, Education, Engineering, Home Economics, Undergraduate)

616.05 SO — Societe de pathologie exotique. Bulletin.
(Veterinary Medicine)

301 Solr 1958 — Society for the Psychological Study of Social Issues. Readings in social psychology.
(Commerce, Education, Journalism)

915 Sp3a — Spencer, J. E. Asia, east by south.
(Agriculture, MAP AND GEOGRAPHY)

Uncat — Steward, J. H., and Shimkin, D. B. Some mechanisms of socio-cultural evolution. From Daedalus. Summer 1961.
MAP AND GEOGRAPHY)

301 St4t — Steward, J. H. Theory of cultural change.
(Commerce, Undergraduate)

591.33 Su8a — Sussman, Maurice. Animal growth and development.
(Biology, MAP AND GEOGRAPHY, Physical Education, Undergraduate)

612.65 T15g — Tanner, J. M. Growth at adolescence.
(Biology, Education, Physical Education)

575.04 T19e — Tax, S., ed. Evolution after Darwin.
(Biology, Commerce, Geology, Natural History Survey)

614.49 T21p	Taylor, I., and Knowelden, J. <u>Principles of epidemiology</u>. (Veterinary Medicine)
577.3 T37o 1942	Thompson, D'A. W. <u>On growth and form</u>. (Agriculture, Biology, Physics)
630.9624 T64a	Tothill, J. D. <u>Agriculture in the Sudan</u>. (Agriculture, MAP AND GEOGRAPHY)
616.9605 TR	<u>Tropical diseases bulletin</u>. (Biology)
338.105 TRO	<u>Tropical science</u>. (Agriculture)
338.1 Un3962f	United Nations Education, Scientific and Cultural Organization. Food and people, a UNESCO project. v. 6. <u>Food, soil, and people</u>. (Agriculture, MAP AND GEOGRAPHY)
572 Un3b	U.S. Bureau of American Ethnology. <u>Bulletin</u>. (Stacks)
630 Un3mi no. 705	U.S. Dept. of Agriculture. Miscellaneous publication. No. 705. <u>Graphic summary of world agriculture</u>. (Agriculture, Natural History Survey, Stacks)
630 Un3al 1957	U.S. Dept. of Agriculture. <u>Yearbook of agriculture</u>: <u>soils</u>. <u>1957</u>. (Agriculture, Biology, MAP AND GEOGRAPHY, Stacks)
333.7 Un395r	U.S. President's Materials Policy Commission. <u>Resources for freedom</u>. (City Planning, Commerce, Engineering, Natural History Survey, Stacks)
Uncat	Washburn, S. L. <u>Tools and human evolution</u>. <u>From</u> Scientific American. v. 203. (MAP AND GEOGRAPHY)
612.01 W67b	Williams, R. J. <u>Biochemical individuality; the basis for genetotropic concept</u>. (Agriculture, Biology, Chemistry, Physical Education, Veterinary Medicine)
Uncat	Williams, R. J. <u>Chemical anthropology - an open door</u>. <u>From</u> American Scientist. v. 46. (MAP AND GEOGRAPHY)
633 W688c	Wilsie, C. P. <u>Crop adaptation and distribution</u>. (Agriculture, MAP AND GEOGRAPHY)

614.05 INT	World Health Organization. Bulletin. (Biology, Veterinary Medicine)
614.06 WOR	World Health Organization. Chronicle. (Stacks)
614 W89m	World Health Organization. Monographic series. No. 8. (Veterinary Medicine)
Uncat	World Health Organization. World Health. Mar.-Apr. 1960; Special issue, 1960; Sep.-Oct. 1961; Extra issue. 1962) (MAP AND GEOGRAPHY)
614.05 WH	World Health Organization. World Health. (Stacks, bound vols.; Undergraduate, current issues only)
312 W94p 1961	Wrong, D. H. Population and Society. (MAP AND GEOGRAPHY)
616.91 Z66r	Zinsser, H. Rats, lice and history. (Agriculture, Biology, Stacks, Undergraduate)
301 Z67h	Zipf, G. K. Human behavior and the principle of least effort. (Engineering, German and Romance Language, Journalism, Labor and Industrial Relations, Stacks)

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 1. The Nature of Human Ecology (Shimkin)

Human ecology seeks to identify common elements, organizational systems, and processes in the vast array of human behavior. Such generalizations, if validly achieved, provide bases for interpretations, classifications and predictions of human activities that are both intellectually elegant and pragmatically needed.

The focus of human ecology, like that of ecology generally, is the interacting population in a specific framework of time, space and habitat. The essence of ecological analysis is the measurement and interpretation of physical transactions within the population, and between the population and its physical and biological environment. Guiding concepts in such interpretations are those of physiological requirements, of differences in state between external and internal environments, and of self-regulatory mechanisms. In the study of societies and communities, physical locations, positions in transactional sequences, and relative biomasses define functions (ecological niches), roles and developmental trends (seral stages). These universal features provide analytical bases for the further typology and interpretation of group and individual behavior.

1. Basic hypotheses

Human ecology, as developed in this course, assumes that regularities in human behavior can be derived from a limited number of general constraints or boundaries and central tendencies, including the following:

a. Man's definable, relatively precise, physiological requirements which can further be restated in terms of physico-chemical tolerances, exchanges and balances.

b. Man's fixed life sequence, which permits the continuity of man only through the social acts of reproduction and the care of helpless young. It also yields sharply different consequences for given physico-chemical and perceptive experiences at varying stages of development and senescence. These provide foundations for role differentiation and cooperation.

c. To an exceptional degree, man's inherited response system is modifiable by learning. The capacity to communicate objective as well as expressive information renders learning cumulative, and underlies a new dimension of adaptation: culture.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 250, Geography 250, Health Education 250,
Psychology 250, Sociology 250, Veterinary Science 250, and
Zoology 250)

Lecture 1. The Nature of Human Ecology ([illegible])

Human ecology seeks to identify common elements, organizational patterns, and processes in the vast array of human behavior. Such generalizations, if clearly articulated, provide bases for interpretations, classifications and predictions of human activities that are both intellectually elegant and pragmatically needed.

The focus of human ecology, like that of ecology generally, is the interacting population in a specific framework of time, space and habitat. The essence of ecological analysis is the measurement and interpretation of physical transactions within the population, and between the population and its physical and biological environment. Guiding concepts in such interpretations are those of physiological requirements, of differentials in state between external and internal environments, and of self-regulatory mechanisms. In the study of societies and communities, physical locations, sequences of transactions, sequences, or relations among specific functions (niches), roles and developments from a causal standpoint. These universal features provide analytical bases for the further synthesis and interpretation of group and individual behavior.

1. Basic Hypotheses

Human ecology, as developed in this course, assumes that regularities in human behavior can be derived from a limited number of general constraints or boundaries and certain tendencies, including the following:

a. Man's organic, relatively precise physiological requirements which can further be restated in terms of physico-chemical tendencies, exchanges and balances.

b. Man's inherited dependency, which permits the continuity of man only through the social acts of reproduction and the care of helpless young. It also permits that many different consequences may given the same chronological and comparative parameters at varying stages of development and senescence. These provide foundations for social differentiation and cooperation.

c. To an exceptional degree, man's inherited response system is modifiable by learning. This capacity is commensurate with objective as well as subjective differentiation renders learning cumulative, and underlies a new dimension of adaptation: culture.

d. Cultural evolution, in common with biological evolution, has led to the development of diversity, specialization and complex interrelationships. But the basic mechanisms of cultural evolution--innovation, pattern formation, diffusion, and integration--have been radically different from the ramification, dispersal and competitive selection characteristic of biological evolution.

e. Man's adaptive capacity has been vastly extended by the use of tools, materials and energy, by plant and animal domestication, and by food preparation. In consequence, man occupies alternative ecological niches, which have permitted his enormous dispersal and population growth.

f. Culture has also created artificial environments, notably the cultivated field and the city, and exercised other selective effects profoundly influencing biological evolution among almost all species.

g. Similarly, culture has increasingly inhibited and transformed into symbolic form major aspects of human motivations and behavior. Such symbolization has had a dual ecological role: self-regulation, e.g., in sexual behavior; and self-stimulation, e.g., in art, religion and war.

h. Analysis of the multi-stage relationships between man and his physical environment, via culture and society, represents a basic aspect in the rational solution of many human problems in health , population management, land utilization and resource development.

2. Corollaries

a. The constraints detailed above are believed to be applicable to all human societies. The ecological features primarily differentiating cultures and subcultures from each other seem to be (1) the nature of the dominant productive processes, e.g. animal-powered agriculture; (2) the spatial organization of the population with associated movements and exchanges; (3) the codes governing status, authority, and means of conflict resolution; and (4) the nature, magnitude and durability of goods and services generated beyond the current consumption levels. These differential classifications reflect the end-effects of particular historical events in particular environments.

b. The essence of ecological analysis is an explicit demonstration of physical interdependencies via circular transactions, e.g. nitrogen exchanges in food chains or cycles of economic exchanges. The coefficient of exchange, i.e. values received in relation to those expended, represent differential costs in a biological or social community and are basic indices of dominance.

3. Data and methods

Human ecology has emerged from the anecdotal stage, has accumulated important bodies of case materials, and has begun rigorous quantification, particularly in biometeorology. At present, the three main areas of needed development are the rigorous limitation of ecology to unequivocally identified elements and interrelationships; the analysis of considerable bodies of extant data from the standpoint of precise mathematical models, e.g., Poisson distributions, Markov chains, etc.; and the development of measures, statistics and analyzed data to bring out, comprehensively and reliably, the parameters of various elements of human ecology, e.g. the comparative labor utilization patterns of various peasant agricultures. A critical approach is essential, for even classical concepts such as floral associations may actually represent subjective interpretations of random coincidences (McIntosh, 1958).

4. Applications.

Epidemiology, a discipline based on identifying disease chains, is the most developed area of applied ecology. Today, it faces increasingly complex problems in viral diseases, cancer and behavioral disorders, while those problems of nutrition which depend on changing economic patterns and food habits remain difficult.

Agriculture presents multiple problems, particularly in connection with the cumulative effects of land abuse, and the hazards of narrowing sources of plant and animal selection. In tropical agriculture the questions of new domestications of plants and animals as sources of protein, and of the maximum utilization for usable product of the immense output of solar energy are particularly acute.

The maximization of amenities, the minimization of travel-times and of traffic hazards, the elimination of air and water pollution, and the maximization of the efficiency of labor and capital encompass the major ecological aspects of regional planning in industrialized societies. In non-industrial societies, the greatest area of ecological application is in the minimization of conflicts between emerging socio-economic forms and the conservation of resources, human and natural, needed for sustained growth.

5. Sources.

The basic reference data comprise a carefully selected set of sources covering the major areas of general and human ecological research. Bates (1961) and Theodorson (1961) are useful summaries; Blum (1955), von Bertalanffy (1960), and von Neumann (1958) present physico-mathematical foundations, including the mechanisms of self-regulation; Huxley (1953), Dobzhansky (1955), and Kendeigh (1961) yield essential knowledge on evolution, genetics, and animal ecology. For human ecology directly, the basic sources

are Kroeber (1939) and Driver and Massey (1957) on preliterate cultures; Singer (1954-58) on the material culture of the Western world; and Thompson (1959), Kiser and Boudreau (1960), and Freedman et al. (1960) on major demographic problems.

Much else can be cited. In the periodical literature, outstanding works include Steward's (1949) comparison of culture growth in the Old and New World; Livingstone's (1958) remarkable analysis of the cultural foundations of malarial infection, and sickle-cell epidemiology in West Africa; and Gregor's (1959) insightful study of competition between agricultural and urban land use in California. Thus this course serves only as an introduction to a vast field of research and application.

Required Reading

Bates, M. Man in Nature, pp. 1-11, 59-79.

Other references

1. Gregor, H.F.: "Push to the desert," Science 129: 1329-1339, 1959.

2. Livingstone, F.B.: "Anthropological implications of sickle-cell gene distribution in West Africa," American Anthropologist 60: 533-562, 1958.

3. McIntosh, R. P.: "Plant communities," Science 128: 115-120, 1958.

4. Steward, J.H.: "Cultural causality and law. A trial formulation of the development of early civilizations," American Anthropologist 51: 1-27, 1949.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369,
Physiology 369, Sociology 369, Vetinary Science 369, and
Zoology 369)

Lecture 2. The Earth's Environment as a Physico-chemical System
(Shimkin)

The essence of science is the integration of particular, seemingly unique, observations into homogeneous general systems of classification, process and prediction. This integrate involves the discovery of common properties and of isomorphism in structures, so that appropriate translations of terms and transformations of relations can generate identities. Valid integrations simplify the interpretation of observed phenomena, are insensitive to minor changes in models and measures, and are likely to uncover attributes hidden to naive views. But integration is always incomplete, because the immense variety of properties of most phenomena eludes description let alone measurement. Furthermore, since all real observations of events and relations are probabilistic rather than categorical, complex and multi-stage systems can be reliable reconstructed from simple, precise measurements. Disaggregation, the discernment of relevant classes, the identification of index measures, scaling, model construction and testing comprise the cycle of analytical approximation, which must be reiterated until satisfactory consistency and comprehensiveness are gained.

Analytical undertakings are still rare in human ecology. Zipf's (1949) studies comprise an insightful but methodologically inadequate attempt to test human behavior as a system of minimizing anticipated effort; Putnam's (1953) work is a broad, comparative evaluation of energy use in comtemporary and future economies, but is vitiated by many factual errors. The Paley Commission's (1952) report is broad and sophisticated, but limited to the materials utilization patterns of the United States alone. Nevertheless, smaller studies and work in plant and animal ecology indicate clearly that human ecology can be usefully systematized in terms of physico-chemical measures.

This systematization applies most strongly to synchronous or short-term analyses, in which components such as the genetic capacities of the biota, and the cumulative effects of long-term geological processes are accepted as invariants. Moreover, the synchronous parameters and forces can usefully be divided into world constants and variables of the natural and cultural terrestrial environment. The former include such factors as the strength of gravity on the earth's surface, and the presence of a high-altitude ozone barrier limiting the penetration of ultra-violet rays. These have profound consequences, e.g. in retaining liquid-phase water and gas-phase oxygen at the earth's surface, in setting limits to bone-skeleton terrestrial sizes, in reducing mutation rates and the velocities of chemical reactions, etc. They set universal patterns.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

These generalizations are central from the standpoint of unifying ecology, including human ecology, and relating it to other observed phenomena. This unity develops from the facts that: (1) man, as a living organism, shows properties comparable with all other forms of life; and (2) man's cultural products, including his social organization, comprise systems the geometry of which and the transactions accomplished by which can be equated with those of other living and even inorganic systems. These comparisons, while in no sense defining culture or yielding an organismic view to culture, are nevertheless fruitful.

Let us examine the physico-chemical aspects of human ecology from the standpoint of man as an organism. His relations must be considered from two aspects, evolution and synchronous or short-term processes. The first is not readily amenable to direct physico-chemical analysis, except in very general terms, e.g. that it is a reflection of astronomical disequilibria; that it is made possible by the high degree of energy absorption of the aqueous system of the earth's surface; and that it represents a reduction in the entropy of the earth's surface--i.e. the development of organization and heterogeneity--through the mechanism of a peculiar, highly active, self-regulating, catalytic system: life.

On the short-term or sychronous level, the possibilities of analyses are greatly increased. These analyses may be divided into two broad classes:

1. Phenomena which are world constants. One of the most fundamental is the strength of the earth's gravitational field. (a) This permits the presence of specific phase states at particular temperatures, e.g. liquid water between 0^{o} and $100^{o}C$ at the earth's surface, gaseous nitrogen and oxygen, etc. (b) Another consequence is the set of structural and physical effects resulting from the interrelationships of (l) the strength of organic materials, (2) the partial pressure of gases in terrestrial environments.

Another world-wide constant is the relative coolness and limited radiational excitation of the earth's surface. This permits (a) low temperature processes of energy and unit transfer, (b) build-up and transferance of thermodynamically unstable giant molecules and (c) low efficiency of work capacity of organic matter.

2. The variable phenomena constitute four types of relations:

(a) Geographical location: Climatic variables and many derived phenomena such as vegetation and soils (Senstius, 1958) can be predicted from latitude, altitude and continentality. The last factor is governed by the rotation of the earth and the relations of land and water masses, but can be directly expressed by the relative frequency of continental and marine air masses in the locality.

These generalizations are general from the standpoint of unified ecology including human ecology, and relating it to other observed phenomena. This unity develops from two facts: (1) man, as a living organism, shares properties of adaptability with all other forms of life, and (2) man's cultural ecology, including his social organization, comprises systems the growth and [illegible] and the [illegible] are regulated by which can be equated with those of other living and non-living systems. These comparisons, important in a sense defining culture or viewing an organism as a [illegible] culture, are nevertheless fruitful.

Let us examine the physico-chemical aspects of human ecology from the standpoint of [illegible] organization. The relations need be considered from two aspects, character and [illegible] processes. The first is [illegible] amenable to physico-chemical analysis, except in very general terms, e.g. that it is a reflection of [illegible] at [illegible]; that it is made possible by the high degree of energy [illegible] of the aqueous system of the earth's surface, and that it represents a reduction in the entropy of the earth's surface — i.e. the development of organization and not degeneration through the mechanism of reproducing, highly complex, self-regulating, [illegible] systems: life.

On the [illegible] or [illegible] level, the possibilities of analyses are greatly increased. These analyses may be divided into two broad classes.

1. Phenomena which are world constant. One of the most [illegible] is the strength of the earth's gravitational field. (a) This permits the existence of specific phase states at [illegible] temperatures, e.g. liquid water between 0° and 100°C at the earth's surface, gaseous nitrogen and oxygen, etc. (b) Another consequence is the set of structural and physical effects resulting from the interrelationships of (a) the strength of organic materials, (b) the [illegible] presence of gases in terrestrial environments.

Another world-wide constant is the relative coolness and limited [illegible] radiation of the earth's surface. This permits (a) low [illegible] temperature processes of energy transformation, the building-up and [illegible] of [illegible] complex large molecules and (b) low efficiency of work capacity of organic matter.

2. The variable phenomena [illegible] two types of relations:

(a) Geographic [illegible]. Although variables and many [illegible] (Schimper, 1898) [illegible] latitude, altitude, and continentality. [illegible] by the [illegible] of the earth and the [illegible] of land and water masses, but can be [illegible] by the relative frequency of [illegible] in the [illegible].

(b) Space and time configurations. The analysis of the distributions of environmental factors, resources, populations and activities in time and space constitutes the fundamental method of translating observations into mathematical functions which then lead to the empirical search for the predicted factors and relations. For example, a linear function indicates the presence of two constants and one operational variable. The most fundamental theoretical distinction between distributions is that between random and non-random types. Among non-random distributions, linear and non-linear continuous functions, and generation functions (lattices, trees, etc.) are basic types. Other measures of distributions: central tendencies, skewness, and the like yield further interpretations. Finally, the relations between distributions, e.g. the transition probabilities of points in successive measures, provide dynamic measures. Overall, the power and flexibility of configurational analyses can be enhanced by use of alternative coordinate systems (orthogonal, polar, cylindrical), and scales (arithmetical, logarithmic, exponential). The significance of formal "analogies" in the discovery of properties has been amply shown by the fruitfulness of information theory as an outgrowth of distributional comparisons with the statistics of entropy (Shannon and Weaver, 1949).

The complexity of temporal concepts, particularly as applied to ecology, needs emphasis: not only duration but sequences and periodicity (e.g. in growth and photosynthesis in plants), not only geophysical but biological time scales are in question. See Strehler and Mildvan (1960).

(c) Energy. Energy studies provide the basis for hierarchical ordering in ecology. In man, the control of exogenous energy through machines has multiplied available energy. Analyses of the energy cycle including levels of efficiency of use, storage, reversibility, etc., yield measures of effectiveness, interdependence, stability and adaptive potentiality which are directly comparable throughout the entire range of ecology.

(d) Materials. Water, nitrogen, phosphorus and iron. Life is an aqueous phenomenon, and agriculture and modern industry, too, utilize far more water than any other substance. Davis and Day (1961) give a fine survey of this phenomenon. Among other materials in the biochemical cycle, nitrogen as the building-block of protoplasm, and phosphorus as the carrier of organic energy are particularly crucial. Note the importance of organisms as geological mechanisms for the transport of these materials (Redfield, 1958). Iron by far the most important metal of industry, indicates the scope of both current and past generating activities (investment).

Required Reading

Blum, H.F.: Time's Arrow and Evolution, pp. 60-86.

Other references

Barthwick, H.A. and S.B. Hendricks: "Photoperiodism in plants," Science 132: 1223-1228, 1960.

Davis, K. S. and J.A. Day: Water. The Mirror of Science. N.Y. Doubleday. Science Study Series, No. 18, 1961, pp. 196.

Paley, W. S. et al.(The President's Materials Policy Commission): Resources for Freedom. 5 vols. Washington (U.S.Govt. Printing Office), 1952.

Putnam, P.: Energy in the Future. N.Y. Van Nostrand, 1953.

Redfield, A.C.: "The biological control of chemical factors in the [illegible] nt environment," American Scientist 46: 205-221, 1958.

Senstius, M.W.: "Climax forms of rock weathering," American Scientist 46: 355-367, 1958.

Shannon, C. E. and W. Weaver: The Mathematical Theory of Communication. Urbana. University of Illinois Press, 1949.

Strehler, B. L. and A. S. Mildvan: "General Theory of Mortality and Aging," Science 132: 14-21, 1960.

Warburg, O. "Photosynthesis," Science 128: 68-73, 1958.

Zipf, G. K.: Human Behavior and the Principle of Least Effort. Cambridge, Addison-Wesley, 1949.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 3. The Evolution of Terrestrial Environments (Shimkin).

Terrestrial life is a phenomenon possible only under highly specialized physico-chemical conditions. The environmental requirements essential, let alone optimal, for individual species are even more restricted. In consequence, environmental variations have greatly intensified the effects of mutation as an evolutionary force by reiterated disturbances in selective advantages and population equilibria.

These variations are basically controlled by geological events, especially cycles of continental uplift or subsidence. Continental drifts in relation to the earth's axis of rotation may also be involved (Ewing and Donn, 1956 and 1958). Astronomical causes, especially cycles of solar activity, have also been proposed. Geological events lead to climatic changes, especially greater or lesser variations in temperature, precipitation and evaporation; moreover, altitudinal changes directly affect mutation rates by intensifying or minimizing variations in cosmic and ultra-violet radiation upon biota. Climate dominates soil development, and exercises major controls upon selection in plants, hence in the dependent food chains. Among the secondary agents of ecological change, man, his symbiotes and his parasites have been especially prominent.

Paleontologically, developments since the Cretaceous period have the greatest relevance for understanding the development of present-day biota. By that time, marine biology had largely modernized (Ladd, 1959), while on land both early flowering plants and placental mammals had appeared. Equable climates reflected general continental peneplanation, while isthmian and insular stepping stones were numerous. In consequence, cosmopolitan dispersions of flowering plants and early mammals were the predominant evolutionary process from the Cretaceous until the early Eocene (Axelrod, 1959; Simpson, 1947). The presence of the breadfruit tree (Artocarpus) in Greenland, and of palms (Palmae) in the Dakotas is illustrative (Seward, 1931, pp. 378-414).

The Oligocene was a period of more limited migration; flows persisted especially between Asia and North America. It was also the beginning of basic changes continuing to the present. These included concurrent mountain building (especially the Alpine-Caucasian-Himalayan system) and marine subsidence (Bering Strait). General cooling, latitudinal temperature zonation and, above all, continental steppes and deserts developed. Associated with drying was an increasing shift in flora from woody to herbaceous; even in England, the

INTRODUCTION TO HUMAN ECOLOGY

[illegible], Geography [illegible], Health Sciences [illegible],

Physiology [illegible], Veterinary Science [illegible]

Spring [illegible]

Lecture 3. The [illegible] environment [illegible]

[illegible] possible only under fairly constant physico-chemical conditions. The environmental requirements [illegible] alone optimum [illegible] even more restrictive. In temperature, [illegible] the effects of evolution [illegible] evolutionary [illegible] disturbances of selective advantages and population equilibria.

These variations are basically controlled by [illegible], especially [illegible] continental drift [illegible]. Continental shifts in relation to [illegible] may also be involved (Dietz and Dunn, 1956 and 1960). [illegible], especially cycles of solar activity, have also been proposed. Whatever events lead to climatic changes, especially [illegible], precipitation and evaporation [illegible] directly affect [illegible] or [illegible] vegetation [illegible] upon [illegible]. Climate [illegible] soil development, [illegible] upon selection [illegible] in the [illegible] food chains. Among the secondary agents of ecological change, man, his symbiotes and his [illegible] have been especially prominent.

[illegible], since the [illegible] the greatest relevance for understanding [illegible] of present [illegible]. By that time, [illegible] had [illegible] (Smith, 1960), while [illegible] both early [illegible] and placental mammals had appeared. [illegible] climates [illegible] general continental [illegible], while [illegible] were [illegible]. [illegible] dispersions of [illegible] plants and early mammals [illegible] evolutionary [illegible] from the Cretaceous until the early Eocene [illegible] 1960 [illegible]). The [illegible] Greenland [illegible] (Seward, 1971 pp. 370-380).

The [illegible] was a period of more limited migration [illegible] especially between Asia and North America. It was also the beginning of basic changes continuing to the present. These included concurrent mountain building [illegible] Bering Strait). General cooling [illegible] all continental steppes and desert [illegible]. Associated with [illegible] increasing [illegible] from wood [illegible] the

proportion of woody species fell from 97 per cent in the Eocene to 57 per cent in the Oligocene. By the Pliocene period it had reached 22 per cent (Dorf,1960). This change meant that more rapidly replenished grasses, with seeds and flowers containing highly concentrated fats, proteins and polysaccharides (Bonner, 1950, esp. pp. 245-279, 352-381), displaced leafy browse for primary herbivore subsistence. Better nutrition undoubtedly accelerated the transition from archaic herbivores and predators, to better-muscled larger-brained modern types. Field rodents developed in symbiosis with grasses. The development of the most specialized ruminants, the deer, antelopes, cattle and their allies (Pecora) began in the Oligocene and reached its climax in the Pliocene (Romer, 1958, pp. 442-474).

Since the Pliocene, world climates have been characterized by relatively low temperatures, with cyclical changes between rather moist episodes of polar glaciation and subtropical storminess, and periods of subarctic storminess and subtropical drought. Intense stresses and physical barriers to migration drastically reduced biotal species in the great Holarctic region from Western Europe through Siberia to the United States--which in its entirety has far fewer life forms than India alone (Dobzhansky, 1950). Local refuges, especially mountainous areas such as Mongolia, and north-south channels, such as the Mississippi, provided the basis of restocking by adaptable, highly mobile, quickly breeding animals. Plants have recovered slowly, especially since the development of extensive and deep permafrost. This took place probably in the later Würm-Wisconsin period when reindeer and Arctic foxes replaced wooly rhinoceri, mammoths and horses as subarctic species.

Man has developed and dispersed in a recent world of isolated, varied biota in the Afro-Asian tropics, in Australia, and in South America; of moderate diversity in temperate Europe, the Far East, and Pacific and eastern America; of monotonous poverty in the deserts, grasslands, dark forests and tundras of the Holarctic core. Through fire, deforestation and cultivation; through direct extermination or through the activities of his symbiotes and parasites, man has accelerated species loss through the world. Domestication has modified a few species; some, such as maize, have become totally dependent upon man for their survival. The dispersal and development of domesticates have also induced major changes in other biota, e.g. plant rusts (Johnson, 1961).

Because agriculture and the domestication of animals developed independently in a considerable number of localities in the Old and New Worlds, and initially involved many species, the widening of cultural exchanges has promoted biotal transfers not otherwise possible in the present world environment. For man, the combination of Eurasian and American resources--wheat, corn, potato, cattle, chickens, etc.--permitted vast world wide increases of population. Yet the displacement of domesticates as well as wild plants and animals is widely evidenced by cultivated exotics in refuge areas such as Ethiopia and the Andes, by historical records and by archeology. Moreover, as Dobzhansky (1950) has noted, northern biota are more characterized by plasticity than by ecological maximization. In particular, dry-land

[illegible] 57 per cent in the [illegible] of 37 per cent in the [illegible]. In the [illegible] period it has reached 21 per cent [illegible] 1960) [illegible] (..., 1961, pp. 174-180).

[illegible]

[illegible]

[illegible] (..., 1961).

[illegible]

field crops, such as wheat have replaced natural rain forests, as in India, only as inefficient, wet-season producers, using only a fraction of the available heat, minerals and moisture.

Today, man's survival depends upon a handful of species, habituated to the artificialities of domestication, and narrowed in response by selection for maximum yield rather than plasticity. The effective development of as yet forbidding habitats and capacity to adapt to environmental changes which are certain to come may not be easy. Environmental control (as by irrigation and perhaps limited weather modification), induced mutations in domesticated species, and chemistry can do much. Yet better use of native biota, e.g. the domestication of the well-adapted, highly productive game animals of Africa (Darling, 1960), deserves serious attention, especially in the tropics and in deserts. In general, the maximum preservation of varied germ plasms in refuge areas, or wildlife conservation, is not mere sentimentality but simple insurance against the unknown demands of future environmental evolution.

Required reading

Kendeigh, S. C., Animal Ecology, pp. 280-292.

or

Dorf, E., "Climatic changes in the past and present," American Scientist 48: 341-364, 1960

and

Dobzhansky, T., "Evolution in the tropics," American Scientist 38: 209-221, 1950.

Other references

Axelrod, D. I., "Poleward migration of early Angiosperm flora," Science 130: 203-207, 1959.

Bonner, J., Plant Biochemistry. New York: Academic Press, 1950, pp. 537.

Darling, F. Fraser, "Wild Life Husbandry in Africa," Scientific American November, 1960, pp. 123-135.

Ewing, M. and W. L. Donn, "A theory of ice ages," Science 123:1061-1066, 1956 and 127: 1159-1162, 1958.

Johnson, T., "Man-guided evolution in plant rusts," Science 133: 357-361, 1961.

Ladd, H. S., "Ecology, paleontology and stratigraphy," Science 128: 69-78, 1959

Romer, A.S., Vertebrate Paleontology. 2d ed., 8th printing. Chicago: Univ. of Chicago Press, 1958. pp. 687.

Seward, A. C., Plant Life through the Ages. New York: Macmillan, 1931.

Simpson, G.G., "Holarctic Mammalian Faunas and Continental Relationships during the Cenozoic," Bull. of the Geological Soc. of Amer. 58:613-688, 1947.

Field crops, such as wheat have replaced natural rain forests, as in India only an inefficient, wet-season producers, using only a fraction of the available heat, nutrients and moisture.

Thus, man's survival depends upon a handful of species, both tied to the artificialities of monoculture, and narrowed in response by selection for maximum yield rather than adaptability. The relative dependence of plant upon fluctuating habitats and capacity to adapt to environmental changes which are certainly in some ways not [illegible]. Environmental control (as of irrigation and pesticides) [illegible] modification); and new mutations and introduction of species [illegible]. Yet better use of native biota, e.g., the domestication of the well-adapted, highly productive game animals of Africa (Darling, 1960), deserves serious attention, especially in the tropics and in deserts. In general, the protection and preservation of varied game plants in refuge areas, or wildlife conservation, is not mere sentimentality but simple insurance against the unknown demands of future environmental alteration.

Required reading

Kendeigh, S. C., Animal Ecology, pp. 380-392.

or

Dorf, E., "Climatic changes of the past and present." American Scientist 48: 341-364, 1960.

or

Dobzhansky, T., "Evolution in the tropics." American Scientist 38: 209-221, 1950.

Other references

Axelrod, D. I., "Poleward migration of early Angiosperm flora." Science 130: 203-207, 1959.

[illegible], J., Plant [illegible]. New York: [illegible], 1958. pp. 5[illegible].

Darling, F. Fraser, "Wild life Husbandry in Africa." Scientific American November, 1960, pp. 123-135.

Ewing, M. and W. L. Donn, "A theory of ice ages." Science 123: 1061-1066, 1956 and 127: 1159-1162, 1958.

Johnson, F., "Man-guided evolution in plant and [illegible]." Science 135: [illegible], 1962.

Ladd, H. S., "Ecology, paleontology and stratigraphy." Science 129: 69-78, 1959.

Romer, A. S., Vertebrate Paleontology. 2d ed., 687 pp. Chicago: Univ. of Chicago Press, 1945, pp. 687.

Seward, A. C., Plant Life through the Ages. New York: Macmillan, 1931.

Simpson, G. G., "Holarctic mammalian faunas and Continental relationships during the Cenozoic." Bull. of the Geological Soc. of Amer. 58: 613-688, 1947.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369,
Physiology 369, Sociology 369, Veterinary Science 369, and
Zoology 369)

Lecture 4. Contemporary Environments (Biomes) (Shimkin).

Thus far we have considered three general topics:

1. The analytical assumptions of human ecology as a partial but systematic approach to defining elements of the biological and behavioral characteristics of man.

2. The statement and partial development of the role of major physico-chemical phenomena in the determination of the nature of terrestrial life, e.g. (a) geophysical phenomena, (b) geometrical relations, and (c) flows of energy and materials.

3. An introduction into the understanding of adaptation as a directional process, in which two phases must be discriminated: (a) The environment in which man entered as the end result of an evolutionary process dominated by the effects of dessication and cooling upon the late Mesozoic biota. (b) Man's effects in the past, especially in accelerating species loss, and his capacities for modifying and his dependences upon other forms of life.

Now we shift to a more detailed assessment of the particular means in which physico-chemical phenomena exercise differential effects upon life forms and result in basically different capacities in the great regions or biomes of the world. These discussions are a first-step in problems to be analyzed further by Professors Kendeigh, Russell and Booth.

Three general points are emphasized:

1. Plants have the most complete biological adjustment to the environment, including climate, geology, topo- and hydrography. In contrast to animals, their adjustments involve fundamental adaptations of the cellular as well as the organic and behavioral levels.

Plants also determine the capacity of animals to use the environment through food chain and through the development of micro-habitats and micro-climates. Thus biomes are basically characterized by natural vegetation.

2. Among terrestrial animals, the fundamental determinants are capacity for access through media for movement, food and refuge for rest and reproduction. Animals can and do invade areas of high stress, e.g. the tundra and high altitudes for periodic use if these fundamental conditions are met. Thus, a basic feature of animal relation to biomes is inter-zonal use, optimizing physiological and behavioral adaptation.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 380, Geography 380, Health Education 380,
Physiology 380, Psychology 380, Veterinary Science 380, and
Zoology 380)

Lecture 4. Contemporary Environmental Concerns (Continued).

Thus far we have considered three general topics:

1. The concept of the ecosystem [illegible] of human ecology as a method for systematic approaches to studying components of the biosphere and behavioral characteristics of man.

2. The historical and cultural development of the role of major physico-chemical phenomena in the determination of the nature of terrestrial life, e.g. (a) geophysical phenomena, (b) geochemical relations, and (c) flows of energy and materials.

3. An introduction into the understanding of succession as a fundamental process, in which two [illegible] must be distinguished: (a) The environment to which man adapted as the end results of evolutionary processes [illegible] by the [illegible] of [illegible] and [illegible] the two [illegible]. (b) man's effects in the past [illegible] in modifying ecosystems, and his capacities for [illegible] that has [illegible] other forms of life.

Now we shall go on to a more detailed assessment of the particular ways in which physico-chemical phenomena [illegible] environmental effects upon life forms and result in [illegible] different conditions in the given regions or climates of the world. These [illegible] are [illegible] in [illegible].

Three general points are emphasized:

1. [illegible] in the environment, [illegible] to [illegible]. These [illegible] involve [illegible] as the organism [illegible].

2. [illegible] through food chains and through the [illegible]. Thus [illegible] of natural vegetation.

3. [illegible] and [illegible] e.g. the [illegible] and [illegible] for [illegible]. Thus, a basic [illegible] is [illegible], physiological and behavioral adaptation.

3. Man shares these features with other animals, but is distinguished by a number of added features--(a) capacity for both micro- and macro habitat alterations; (b) capacity for exchange through adjustments of local surpluses and deficits; (c) capacity for inhibitation and symbolization which reduce competative processes and develop new objects.

In man relations to biomes have thus become more generalized. The crucial features are those of specialized surpluses, contact, and exchanges, i.e. relation to the broader human society. Concentrated resources, e.g. agriculture and mining, are especially worked. But human beings still reflect the underlying constraints even in industrialized societies, i.e., the constraints of availability of food and climatic stress. Thus the major habitat areas are deciduous forests (China, Western Europe, and U.S.), chaparral (Mediterranean) and grasslands. Limited entry can be seen in the desert, boreal forest, and arctic regions.

In terrestrial environments, the most comprehensive yet sensitive bases of ecological classification are determined by the characteristic forms of native vegetation, as exhibited both in relatively stable climaxes and in serial associations. Plant root development, size, density and temporal patterns of activity reflect the effects of climatic variables--sunlight, temperature, wind and water balance; of physiography; and of faunal activity. Overall, the world's terrestrial environments can be grouped into nine basic biomes: tropical, temperate deciduous, and coniferous forests; chaparral; tropical savanna, grasslands, deserts; alpine; and arctic. In continuity of biological activity and in the gross annual output of biological mass, these biomes range from tropical forest to arctic, in descending scale. However, natural and artificial grasslands, i.e. field crops, produce a maximum of concentrated food for mammals. (Kendeigh, 1961, esp. pp. 276-350).

The habitats of birds and mammals are determined primarily by food habits, the means of acquiring moisture, and by patterns of rest, reproduction and care of the young. Social factors such as territoriality and group migration are also important in population dynamics (Errington, 1956). Cover and protection from predation are significant. Adaptations to physiological stresses, especially temperature and moisture control, vary in type: morphological selection, as expressed by Bergmann's, Allen's and Rensch's rules; behavior in action at maximum stress, via hibernation or estivation; micro-habitat selection or development to escape stress; and migration. Although some generalities are evident, e.g. the predominance of morphological adaptation in ruminants, of micro-habitat development via burrows and food storage among rodents, and of migration among birds, the response patterns to stress are highly varied. Thus, among North American weasels, the ermine (Mustela erminea) increases regularly in size from least in tropical to largest in windy arctic localities, in accord with Bergmann's rule. However, Mustela rixosa, the least weasel, lives in the high Arctic, as a predator on lemmings within the snow micro-habitat. And the long-tailed weasel, Mustela penata, which ranges from British Columbia to Bolivia, reaches its greatest sizes in the tropics (Hall, 1951). Finally, although a few mammals and birds have

2. Man shares these features with other animals, but is distinguished by a number of adaptive features: (a) capacity [illegible] to modify [illegible] (b) capacity for [illegible] achievements of food surplus and facilities, (c) capacity to control [illegible] which reduce [illegible] processes [illegible].

In man relations to biomes have thus become more generalized. The critical features are those of specialized purposes, control, and [illegible], i.e. relation to the broader human society. Concentrated [illegible], e.g. agriculture and grazing, are essentially [illegible]. Our [illegible] still reflect the underlying constraints even in industrialized societies, e.g. [illegible] of availability of food and [illegible] streams. Thus the major [illegible] deciduous forests (China, Western Europe, and U.S.), [illegible] and grasslands. Limited entry [illegible] forest, boreal forest, and arctic regions.

In terrestrial environments, the most comprehensive [illegible] bases of ecological classification are represented by the characteristic [illegible] of native vegetation, as exhibited both in [illegible] climaxes and in serial associations. Plant root development, size, density and [illegible] patterns of activity reflect the effect of climatic variables—sunlight, temperature, wind and water balance—of physiography, and of biotic activity. [illegible] the world's terrestrial environments can be grouped into [illegible] biomes: tropical, temperate deciduous [illegible] forests, [illegible] savannas, grasslands, deserts, alpine environments. In [illegible] of biological activity and in the gross [illegible] output of biological mass, these biomes range from tropical forest to arctic, in descending scale. However, natural and artificial grasslands, i.e. field crops, [illegible] food for mammals. ([illegible], 1961, [illegible] pp. 375-387).

The habitats of birds are determined by [illegible] primarily by food habits, the nature of [illegible] and by patterns of nest [illegible] and care of the young. Social factors such as territoriality and [illegible] are also important in population [illegible] ([illegible], 1956). [illegible] and protection from predation are significant. Adaptations to physiological stresses [illegible] dependent on temperature and moisture [illegible] morphological selection, as [illegible] by Bergmann's, Allen's and Gloger's rules, [illegible] to [illegible] stresses, [illegible] hibernation or estivation [illegible] selection [illegible] adjustment to [illegible] stresses and migration. Although some generalities are evident, e.g. the predominance of morphological adaptations in mammals, [illegible] development with burrows and food storage among rodents, and of migration among birds, the response patterns to [illegible] are highly varied. Thus, among North American weasels, the ermine (*Mustela erminea*) increases regularly in size from least in [illegible] to largest in [illegible] in accord with Bergmann's rule. However, *Mustela rixosa* [illegible] the least weasel, [illegible] the North Arctic, [illegible] within the [illegible]. And the long-tailed weasel, *Mustela frenata*, which ranges from British Columbia to [illegible], reaches its greatest size in the tropics (Hall, 1951). Finally, [illegible]

obligatory habitats and restricted ranges, the utilization of varied habitats for procuring food, for nesting and other needs appears more widespread. In general, environmental use by mammals and birds involves a web of cyclical movement between primary and secondary foci of activity.

Man's relations to biomes or natural environments must be viewed from two general aspects: responses and alterations. Man's responses have included definite morphological adaptations on the levels of both gross and micro-structures. The importance of intense solar radiation in the presence of nudity, and of malaria, as selective factors favoring dark pigmentation and the sickle-cell gene, respectively, seem clearcut. Other relations are very complex. Thus, body size and limb length among American Indian populations correspond excellently to Bergmann's and Allen's rules (Newman, 1953); however, the same relations do not hold in Asia. Examination of the matter shows better reflections of cold and heat stresses among prehistoric than among contemporary Asiatic populations. In general, later migrations and the genetic stability of rather large interbreeding populations among Asiatic farmers and pastoralists have offset local environmental selection. Conversely, the dwarfing effects and osteological changes of dietary inadequacies on entire human populations have been excellently shown by studies of changes in size and structure among Japanese, Jewish and Italian immigrants to the United States. (Shapiro, 1939).

Behavioral adaptations in man are also varied. Similar cold stress conditions in Tierra del Fuego and the Aleutians had entirely different correlates in clothing and housing. The exploitation of the tropical forests by Burmese and by Amazonian Indians has also been incomparable. Nevertheless, major environmental factors are never eliminated by man; the adaptations may be submerged yet influential. For example, in maximum use of tropical-forest biomes in agriculture, as by the Chinese, and in the maximum use of temperate deciduous forests, as by the Danes, a basic difference in annual cycles persists. There is continuous activity, with two to three harvests per year, in one case, and periodic activity, with one harvest, in the other; the productivities per acre-year and the distribution of human efforts are correspondingly different. Even in urbanized societies the reflections of biomes are manifold. In the United States, the patterns of population distribution are markedly different in the deciduous forest, grasslands, and complex chaparral-desert-grassland-forest biomes of the West. The effects of waterways, topographical barriers and random location in undifferentiated plains are discernible as forces of different strength in each.

Human alterations of natural environments have been most pervasive in the temperate deciduous and grasslands biomes, in which most of the world's population lives. These alterations may be expressed in terms of four processes: physical destruction and reconstruction, pollution, biological depletion, and biological reconstruction. Fire has been man's oldest means of environmental alteration; increased grazing for game and land clearance, accompanied by ash fertilization, for agriculture have been major objectives.

[illegible] restricted ranges, the cultivation of varied habitats for [illegible], [illegible] other traits [illegible]. In general, [illegible] in mountains and [illegible] a [illegible] cycle of [illegible] primary and secondary [illegible].

Human responses to stresses of natural environments must be viewed from two [illegible]. [illegible] have the [illegible] morphological adjustments on the levels of both gross and micro-structure. The [illegible] of [illegible] in the presence of [illegible] as selective factors favoring [illegible] the [illegible], respectively, seem clear. Other relations are very complex. [illegible], body size and limb length among American Indian populations correspond [illegible] to Bergmann's and Allen's rules (Newman, 1953). However, [illegible] relations [illegible]. Examination of the matter [illegible] of cold and heat stresses among prehistoric man among contemporary [illegible] populations. In general, large migrations and the [illegible] large [illegible] populations among Asiatic farmers and pastoralists have [illegible] offset local environmental selection. Conversely, [illegible] and osteological changes of [illegible] on [illegible] have been excellently shown by studies of changes in size and [illegible] among Japanese, Jewish and Italian immigrants to the United States. (Shapiro, 1939).

[illegible] environments [illegible] are also varied. Simultaneous [illegible] conditions in [illegible] and the Aleutians [illegible] entirely [illegible] [illegible] in clothing and housing. The exploitation of the tropical forests by [illegible] and by [illegible] has also been [illegible]. Nevertheless, [illegible] factors are never eliminated by [illegible] [illegible] yet influential. For example, in [illegible] use of [illegible] in agriculture, as by the [illegible], and in the maximum use of [illegible] forests, as by the [illegible], a basic difference in [illegible] persists. There is continuous activity, with two to three harvests per year, in one case, and periodic activity, with [illegible] in the other; the [illegible] per acre per year and the distribution of [illegible] [illegible] differ. Even in urbanized societies the [illegible] of [illegible]. In the United States, the patterns of population distribution [illegible] markedly different in the deciduous forest, grasslands, and [illegible]-desert-grassland-forest biomes of the West. The [illegible], topographical barriers and random location in [illegible] as forces of different strength in each.

[illegible] alterations of natural environments have been most pervasive in the [illegible] and grasslands biomes, in which most of the world's population lives. These alterations may be expressed in terms of four processes: [illegible] and reconstruction, pollution, biological depletion, and [illegible]. This has been man's oldest means of environmental [illegible] for game and land clearance, accompanied by [illegible] for agriculture, have been major objectives...

Coniferous forest and chaparral are especially vulnerable to fire. Intense grazing and browsing exercise selective controls on vegetation, and also open the way for irreversible erosion, especially on slopes, and in humid areas underlain by limestones (Pyrenees, Yucatan). These are the most extensive effects associated with man. Cultivation is generally localized; it covers some 70 to 80 per cent of prime producing areas such as the Black Earth belt of European USSR and the U.S. corn belt, perhaps a third of the world's natural temperate deciduous forest and grassland areas, and much smaller fractions of other biomes. Industrial, transport and urban developments drastically change environments; Doerr and Guernsey's (1956) analysis of the physiographic impacts of strip coal mining is illustrative. However, except for the pollution of water habitats, these effects are usually localized. Urbanization, in fact, is associated with population concentration, withdrawals from cultivation, and the redevelopment of empty areas (Klimm, 1954). Stabilized urban and agricultural associations, as in Western Europe, are, in fact, associated with artificially developed soils, plantings, and animal life of considerable density.

Every natural biome, even in its altered variants, has characteristic patterns and processes. These may be illustrated by some basic contrasts between the tropical forest and arctic biomes. The tropical forest reflects uniform temperatures, rarely below 10°C or above 40°C; humidity is high, and rainfall considerable even in dry seasons. Chemical and biological activities are intense; leaching, water-logging, and shade constitute limiting factors. For plants, rot and insect are major threats, so poisons, gums and other protective mechanisms have high selective value, as does height. Food shortages limit animal life, and favor dependence upon specialized, reliable sources; hence, a multiplication of niches. Conversely, the stability of the environment gives little value to food storage.

In the arctic biome, on the other hand, the intense seasonality of life is most striking; at latitude 70°N, about 85 per cent of the year's sunlight comes between April and September. Temperature differences, from maxima of about 15°C to minima of -55°C are intensified by severe wind action, which limits plant life to low-lying forms and sheltered areas. Precipitation is low, and water availability also limited by permafrost. Chemical activities are minimal, and mechanical weathering, especially through frost, most active. Limits on root development inhibit higher plants; mosses, lichens and their allies form climaxes. (Polunin, 1955). Food, especially berries, preserved over the winter constitutes a major supply for early migrant water birds, and for reindeer. Competition with insects inhibits mammalian use of the tundra in summer; while winter winds restrict life largely to the snow micro-climate.

Required Reading

Kendeigh, Animal Ecology, pp. 293-300, 324-331, 340-350.

Coniferous forest and chaparral are especially vulnerable to fire. Intense grazing and browsing exercise selective controls on vegetation, and also open the way for irreversible erosion, especially on slopes, and in humid areas underlain by limestones (Pyrenees, Yucatan). These are the most extensive effects associated with man. Cultivation is generally localized; it covers some 70 to 80 per cent of prime productive areas such as the Black Earth belt of European USSR and the U.S. corn belt, perhaps a third of the world's natural temperate deciduous forest and grassland areas, and much smaller fractions of other biomes. Industrial, transport and urban requirements drastically change environments. Deep and Sweetsey's (1960) study of the physiographic impacts of strip coal mining is illustrative. However except for the pollution of water habitats, these effects are usually localized. Urbanization, in fact, is associated with population concentration, withdrawals from cultivation, and the redevelopment of empty areas (Gottmann, 1961). Stabilized urban and agricultural associations, as in Western Europe, are, in fact, associated with actively developed soils, vegetation, and animal life of considerable density.

Every natural biome, even in its altered variants, has characteristic patterns and processes. These may be illustrated by some basic contrasts between the tropical forest and arctic biomes. The tropical forest reflects uniform temperatures rarely below 18°C or above 35°C; humidity is high, and rainfall remains high even in dry seasons. Chemical and biological activities are intense: leaching, water logging, and shade constitute limiting factors. For plants, rot and insects are major threats, so poisons, thorns and other protective mechanisms have high selective value, as does height. Food shortages limit animal life, and favor dependence upon specialized, reliable sources; hence, a multiplication of niches. Conversely, the stability of the environment gives little value to food storage.

In the arctic biomes, on the other hand, the extreme seasonality of life is most striking. At 70°N, about 85 per cent of the year's sunlight comes between April and September. Temperature differences, from maxima of about 15°C to minima of -40°C, are accentuated by severe wind action which limits plant life to low-lying forms and sheltered areas. Precipitation is low, and water action is often limited by permafrost. Chemical activities are minimal, and mechanical weathering, especially through frost, most active. Thus, soil development is limited; higher plants are rare; lichens and their allies form climaxes (Polunin, 1959). Food, especially for animals, is scarce over the winter; herbivores depend on migrant water birds, and reindeer. Competition with insects reduces the mammalian use of the tundra in summer; in winter animals avoid the rigors by using snow micro-climate.

Required Reading

Kendeigh, Animal Ecology, pp. 243-266, 312-331, 384-396.

Other references

Dobzhansky, Theodosius: "Evolution in the tropics," American Scientist: 38: 209-221, 1950.

Doerr, Arthur and Guernsey, Lee: "Man as a geomorphological agent: the example of coal mining," Annals of the Association of American Geographers: 46: 197-210, June 1956.

Errington, P. L.: "Factors limiting higher vertebrate populations," Science 124: 304-307, 1956.

Hall, E. R.: American Weasels. Univ. of Kansas Publ. Mus. of Natl. Hist. 4: 1-466, 1951.

Klimm, Lester E.: "The empty areas of the northeastern United States," The Geographical Review: 325-345, July 1954.

Newman, M.T.: "The application of ecological rules to the racial anthropology of the aboriginal New World," American Anthropologist 55: 311-327, 1953.

Polunin, Nicholas: "Aspects of Arctic botany," American Scientist 43: 307-322, 1955.

Shapiro, H.L.: Migration and Environment. London: Oxford Univ. Press, 1939.

Wedel, Waldo R.: "Some aspects of human ecology in the central plains," American Anthropologist 55: 499-514, 1953.

References

Dobzhansky, Theodosius: "Evolution in the tropics," American Scientist, 38: 209-221, 1950.

Doerr, Arthur and Guernsey, Lee: "Principles of geography as applied to the example of coal mining," Annals of the Association of American Geographers, 46: 197-210, June 1956.

Errington, P. L.: "Factors limiting higher vertebrate populations," Science, 124: 304-307, 1956.

Hall, E. R.: American Weasels, Univ. of Kansas Publ., Mus. of Nat. Hist. 4: 1-466, 1951.

Hewes, Leslie H.: "The empty areas of the north-central United States," The Geographical Review, [illegible], July 1964.

Newman, M. T.: "The application of ecological rules to the racial anthropology of the aboriginal New World," American Anthropologist 55: 311-327, 1953.

Polunin, Nicholas: "Aspects of Arctic botany," American Scientist 43: 307-322, 1955.

[illegible], H. L.: Migration and Distribution, London: Oxford Univ. Press, 1953.

Wedel, Waldo R.: "Some aspects of human ecology in the central plains," American Anthropologist 55: 499-514, 1953.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369,
Physiology 369, Sociology 369, Veterinary Science 369, and
Zoology 369)

Lecture 5. Physiological and Morphological Mechanisms in Homeostasis (Sargent)

Every organism is characterized by three basic features: (1) an organizational identity and isolation from the surrounding environment by means of a membrane barrier; (2) a defined range of activities systematically varying through time and maintained by genetic and other self-regulatory devices; and (3) identity, organization and activity achieved through a series of complex exchanges with the environment by means of which the organism captures enough energy and maintains appropriate balances to keep its internal structure in a relatively steady state called homeostasis.

Organisms are not mechanistic aggregates of components and processes. Parts behave differently in isolation than when in the living organism. An organism is a hierarchy of composing parts in a hierarchy of organizing relations (Woodger, 1924). As a consequence of its organization, the organism exhibits adaptiveness and apparent purposiveness of structure and function.

Organism and environment are inseparable. When thinking of living organisms, one must consider an outer or extra-organismic environment and an inner or intra-organismic environment. The conditions necessary for life are found neither in the inner or outer environments but in both at once (Bernard, 1949).

Organisms are happening, not in being; matter and energy perpetually stream through the organism and at the same time constitute the organism (von Bertalanffy). Thus organisms are open systems. The matter from the external environment becomes highly organized in specific ways. The flow of matter and energy is organized in such a way that the organism represents a steady state.

The matter and energy requirements of the organisms are met by breathing and eating. The energy, which is derived from the sun, is stored in the plants by photosynthesis. Organisms require a constant intake of matter and energy, i.e. energy and nutrient balances must be maintained to sustain life. Each species has specific energy and nutrient requirements. Most species can adjust to undernutrition but none can adjust to dehydration. Energy is consumed in metabolic processes and by homeostatic mechanisms. Heat produced in catabolic reactions must be dissipated so that the organisms can remain in heat balance. Oxygen is required to make this energy available to the cells and tissues. As a result of catabolic reactions metabolic wastes, which are largely acidic in nature, are produced. These wastes must be buffered so that harmful changes in the acid-base balances do not develop; the buffered metabolic wastes are transported to the lungs and kidney for elimination.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 180, Geography 289, Health Education 349, Physiology 199, Sociology 289, Veterinary Science 319, and Zoology 199)

Lecture 1: Physiological and Morphological Mechanisms of Homeostasis (Sargent)

Every organism is characterized by three basic attributes: (1) an organizational identity which sets it apart from the surrounding environment by means of a membrane or container; (2) a defined range of responses to the environment varying through time as determined by genetic and other self-regulating devices; and (3) a flexible, opportunistic and actively achieved (through a system of controls) exchange with the environment by means of which the organism captures enough energy and nutrients appropriate [illegible] to maintain its structure in a relatively steady state called homeostasis.

Organisms are not mechanistic aggregates of components and processes. Parts behave differently in isolation than when in the living organism. An organism is a hierarchy of interacting parts in a framework of interacting relations (Woodger, 1929). As a consequence of its organization, the organism exhibits adaptiveness and apparent purposiveness of structure and function.

Organism and environment are inseparable. With highly developed organisms, one must consider an outer or extra-organismic environment and an inner or intraorganismic environment. The conditions necessary for life are found neither in the inner or outer environment but in both at once (Bernard, 1949).

Organisms are in a state of flux, energy and matter are flowing continually in a stream through the organism and at the same time constitute the organism (von Bertalanffy). That is, organisms are open systems. The matter from the external environment becomes highly organized in specific ways. The flow of matter and energy is regulated in such a way that the organism approaches a steady state.

The matter and energy requirements of the organisms are met by breathing and eating. The energy, which is derived from the sun, is stored in the plants by photosynthesis. Organisms require a constant intake of matter and energy, i.e., energy and nutrient balances must be maintained in the diet. Each species has specific energy and nutrient requirements. Most species can adjust to undernutrition but none can adjust to dehydration. Energy is consumed in metabolic processes and by homeostatic mechanisms. Heat produced in metabolic reactions must be dissipated so that the organism can remain in heat balance. Oxygen is required to make this energy available to the cells and tissues. As a result of metabolic reactions metabolic wastes, which are largely acidic in nature, are produced. These wastes must be buffered so that harmful changes in the acid-base balances do not develop, and [illegible] metabolic wastes are transported to the lungs and kidney for elimination.

The animals from which the primates and the genus *Homo* ultimately evolved originated in the sea. Ages ago the primate antecedents migrated onto the land. That the ancestors of man survived the migration was the consequence of their fitness (L.J. Henderson) for maintaining life in a terrestrial environment rather than in a marine environment. The properties which comprise this fitness constitute basic physiological regulations, viz. (1) resistance to desiccation (regulation of body water); (2) maintenance of a relatively constant temperature in a variable external environment (homeothermy); (3) adjustment to the influences of gravity; (4) resistance to the influences of solar radiation; (5) provision of a moist surface across which atmospheric oxygen can diffuse; (6) provision of an aqueous environment for conception and development of fertilized egg; and (7) provision for parental care for the offspring.

The major function of physiological regulatory mechanisms is to maintain relatively constant the chemical and physical properties of the aqueous milieu interieur (C. Barnard) of the organism. This inner environment bathes the cells and tissues of the body and has physico-chemical properties remarkably similar to the marine environment from whence terrestrial animals evolved. The state of dynamic equilibrium which is maintained in the internal environment has been identified as *homeostasis* (W. B. Cannon). The related regulating processes can be thought of as homeostatic mechanisms.

Homeostatic mechanisms or physiological regulations operate by detecting deviations (excesses or deficiencies) from set points. Sensitivity of enteroceptive mechanisms are related to the capacity of the organism to survive excesses or deficiencies. Homeostatic mechanisms operate by feedback processes:

$$\text{Stimulus} \longrightarrow \text{Recepter} \xrightarrow{\text{(Message)}} \begin{array}{c}\text{Control}\\ \text{Apparatus}\end{array} \xrightarrow{\text{(Message)}} \text{Effector} \longrightarrow \text{Response}$$

Feedback

Homeostatic processes exhibit a phylogeny which illustrates the concept of stabilizing evolution (Schmalhausen, Koshtoyants). Nerveless organisms show a direct response to the outer environment by metabolic reactions. Organisms with nervous systems exhibit indirect responses. Receptors detect environmental changes and signal control devices to initiate adaptive responses. The stimuli for nerveless organisms still retain their significance for organisms with nervous systems: they become stimuli for special extero- and enteroceptive receptors of the nervous system, *e.g.* oxygen, carbon dioxide saturation, temperature, light, osmotic conditions, certain electrolytes, etc. Metabolic adaptations continue important. The metabolic state of the receptors takes part in reactions, for receptors are energy transducers. Neuro-regulatory processes depend upon specific metabolic products such as hormones and neurohumors.

The principle [illegible] which [illegible] the [illegible] of Homo [illegible] [illegible] of the [illegible] [illegible] [illegible] with the [illegible]. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] environment. The [illegible] [illegible] [illegible] (1) [illegible] (2) [illegible] [illegible] (3) [illegible] the influences of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

The [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

[illegible] [illegible]

[illegible] [illegible] [illegible]

[illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

These organismic concepts will be illustrated in a consideration of the physiological regulation of body temperature and acid-base balance.

Required Reading

Scholander, P. F.: Evolution of climatic adaptation in homeotherms. Evolution, 9: 15-26, 1955.

von Bertalanffy, L.: Problems of Life. An Evaluation of Modern Biological and Scientific Thought. Harper Torchbooks (TB 521), Harper and Bros., N.Y., 1960. pp. 123-146.

Other references

Adolph, E. F.: Physiological Regulations. Cattell, Lancaster 1943.

Adolph, E. F.: Early concepts of physiological regulations. Physiol. Rev., 41: 737-770, 1961.

Adolph, E. F. (ed): The Development of Homeostasis. Academic Press, N.Y., 1960.

Bernard, C.: Introduction to Experimental Medicine. Schuman, N.Y., 1949.

Cannon, W. B.: The Wisdom of the Body. Norton, N.Y., 1932.

Henderson, L. J.: The Fitness of the Environment. Beacon Press, Boston, 1958.

Prosser, C. L.: Perspectives of adaptation: theoretical aspects. Handbook of Physiology - Environment. Section 4, (.D.B. Dill, ed.) Am. Physiol. Soc., Washington, 1964. pp. 11-25.

These organisms vary widely with ... [illegible] ... the ... [illegible] regions, ... [illegible] ... temperature and ... [illegible].

General Reading

Scholander, P. F. Evolution of climatic adaptation in homeotherms. Evolution, 9: 15-26, 1955.

von Bertalanffy, L. Problems of Life. An evaluation of modern biological and scientific thought. Harper Torchbooks TB 521. Harper and Bros., N.Y., 1960. pp. 1-216.

Other references

Adolph, E. F. Physiological Regulations. Cattell, Lancaster, 1943.

Adolph, E. F.: Early concepts of physiological regulations. Physiol. Rev. 41: 737-770, 1961.

Adolph, E. F. (ed.) The Development of Homeostasis. Academic Press, N.Y., 1960.

Bernard, C. Introduction to Experimental Medicine. Schuman, N.Y., 1949.

Cannon, W. B. The Wisdom of the Body. Norton, N.Y., 1939.

Henderson, L. J. The Fitness of the Environment. Beacon Press, Boston, 1958.

Prosser, C. L. Perspectives of adaptation: theoretical aspects. Handbook of Physiology - Adaptation to the Environment. Section 4, (D. B. Dill, ed.) Am. Physiol. Soc., Washington, 1964, pp. 11-25.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369 and Zoology 369)

Lecture 6. Processes of Growth, Maturation and Ageing (Sargent)

The life cycle of an organism can be viewed as an ever-changing developmental trajectory which is determined by the interaction between the genotype and the environments through which the organism passes. The main processes of this sequence are growth, maturation and senescence. The fundamental characteristics of these developments are (1) that they progress in an orderly fashion, and (2) that they leave the organism in a different and irreversible state at each stage. The trajectory begins with the fertilization of the ovum and involves growth, cellular differentiation, and morphogenesis. From conception to maturity the physical development of the organism follows an S-shaped curve. When the organism has matured, physical growth terminates and the capacity for reproductive activity begins. The animal releases sperm or ova which originate a new cycle of development. From maturity the animal experiences degenerative changes which ultimately lead to death.

The orderly sequence of the stages in the developmental trajectory represents the integrative action of a complex of processes. A biological "clock," or a number of "clocks," may be responsible for the timing of these processes. How the rhythm of this "clock" is set has not yet been determined. Some investigators argue that it is endogenous; others claim that it is regulated by environmental or cosmic forces.

Prior to maturity there is little dimorphism. Females are more advanced physiologically and mature earlier. After maturity is attained, the dimorphism is marked. The adolescent period is a physiological crisis but is nevertheless holistic or integrated. Skeletal calcification, permanent teeth, body size and weight, and sexual characteristics are intercorrelated.

When the period of maturation is defined as the interval from birth to adolescent growth spurt, one finds that species vary widely in the rate at which they mature:

Animal	Period	Animal	Period
Guinea pig	40-100 days	Cattle	8 - 12 months
Mouse, rat	30-50 days	Rhesus monkey	2 - 4 years
Sheep	6 - 8 months	Chimpanzee	7 - 10 years
		Man	11-16 years

The slow maturing of man may be related to the processes of acculturation.

INTRODUCTION TO ANIMAL BIOLOGY
(Anthropology [illegible], Geography [illegible], Human Resources [illegible], Physiology [illegible], Psychology [illegible], Veterinary Science [illegible] and Zoology [illegible])

Lecture 9. Processes of Growth, Maturation and Aging (Sorger)

The development of an organism can be viewed as an interaction of developmental sequences that are determined by the interaction between the genotype and the environments through which the organism passes. The main processes of these sequences are growth, maturation and senescence. The fundamental characteristics of these developments are (1) that they progress in an orderly fashion, and (2) that they move the organism in a different and irreversible step at each stage. The trajectory begins with the fertilization of the ovum and involves growth, cell [illegible] differentiation, and morphogenesis. From conception to maturation the physical development of the organism follows an S-shaped curve. When an organism has matured, physical growth terminates and the capacity for reproductive activity begins. The animal releases sperm or eggs which originate a new cycle of development. From maturity the aging or senescence degenerative changes occur ultimately lead to death.

The orderly sequence of the stages in the development of the body represents the integrated action of a complex of processes. A biological "clock," or a number of "clocks," may be responsible for the timing of these processes. How the rhythm of the "clock" is set has not been determined. Some investigators argue that it is endogenous, while others think it is regulated by environmental or exogenous forces.

From birth to maturity there is little dimorphism. Sexual dimorphism is determined by [illegible] and [illegible]. After maturity is attained the dimorphism is [illegible]. The senescent period is a gradual one, but it is nevertheless [illegible]. Skeletal calcification, loss of teeth, bone size and weight, and sexual characteristics are then [illegible].

When the period of maturation is defined as the interval from birth to complete [illegible], the [illegible] species vary widely in the age at which they mature:

Animal	Period	Animal	Period
Guinea pig	[illegible] days	Cattle	3 - [illegible] [illegible]
[illegible]	[illegible] days	Rhesus monkey	2 - [illegible] years
[illegible]	8 - [illegible] months	Chimpanzee	7 - 10 years
		Man	11-15 years

The earlier maturation of man may be related to the presence of [illegible]

The maintenance of stability within the open-systems of the organism is the task of the homeostatic mechanisms. The adaptability of the organism is a function of the maturity of the homeostatic mechanisms. The fact that the adaptive capacity of homeostatic mechanisms parallel the life sequences presumably resutls from the fact that the mechanisms evolved from selection pressures exerted during the phylogeny of the species. The mechanisms function most effectively during pre-reproductive and reproductive periods because the adaptive value of the genotype can be transferred to the gene pool of the species only at this time. Natural selection does not operate after this time.

Ageing is the increasing liability to die. Strehler views the evolution somewhat as follows: organisms are organized dynamic systems capable of coupling free-energy and matter for survival and reproduction. Organisms persist because they effectively reproduce and survive despite an inconstant environment. The energy transducers of adapting organisms include growth, maintenance and repair. Ageing is the consequence of imperfect development of maintenance and repair transducers. Perhaps ageing is an accidental by-product of adaptations that had survival value in infancy and childhood. J.S. Holdane views death itself as an effective mechanism of evolution.

The organism is particularly vulnerable to stresses from its total environmental surroundings during certain stages of its life sequence, notably while it is an embryo, a newborn, an adolescent, and aged. Among the environmental impacts which modify the orderly sequence of this developmental trajectory are under- or malnutrition, environmental temperature, noxious agents from the physical and biotic environment, and stresses arising from the cultural environment.

Since the genotype is past-oriented by virtue of the evolutionary process, the norm of reaction of the organism may not be adequate for new experiences. Thus organisms tend to exhibit abnormal reactions to environmental conditions never before experienced. Such reactions have been termed morphoses (Schmalhausen). Iatrogenic diseases and molecular diseases are, in many instances, morphoses.

Required Reading

Brown, F.A., Jr.: The rhythmic nature of animals and plants. Am. Scientist, 47: 147-168, June, 1959.

Gray, G. W.: Human growth. Scientific American, 189: 65-76, Oct. 1953.

Shock, N.W.: The physiology of ageing. Scientific American, 206: 100-111, Jan. 1962.

Sussman, M. Animal Growth and Development. Prentice-Hall, Inc., Englewood Cliffs, N.J., 1960. pp. 1-5; 92-102.

The maintenance of constancy within the internal environment of the organism is the task of the homeostatic mechanisms. The adaptation of the organism is a function of the [illegible] of the homeostatic mechanisms. The fact that the [illegible] of [illegible] has [illegible] results from the fact that the homeostatic system [illegible] changes during the ontogeny of the organism. These mechanisms function most effectively during [illegible] and [illegible] periods because the adaptive value of the genotype can be transmitted to the gene pool of the population at this time. [illegible] after this time.

Aging is an increasing inability to adapt. Shock [illegible] the evolution [illegible] as follows: organisms are [illegible] systems capable of coupling free-energy and [illegible] reproduction. Organisms persist because [illegible] in a constant environment. The [illegible] of [illegible] growth, maintenance and repair. Aging is the consequence of [illegible] of maintenance [illegible]. [illegible] aging [illegible] Haldane [illegible] as a reflection [illegible] of evolution.

The organism is particularly vulnerable to [illegible] environmental [illegible] certain stages of its life [illegible], namely when it is an embryo, [illegible], or adolescent, and aged. [illegible] the environmental [illegible] sequence [illegible] develop [illegible] arising from the [illegible] environment.

Once the genotype [illegible] of the evolutionary process, the [illegible] of the organism [illegible] to new [illegible]. [illegible] organisms tend [illegible] biochemical [illegible] of environmental conditions [illegible]. Such [illegible] Schmalhausen [illegible].

Selected Reading

Baker, [illegible] The rhythmic nature of [illegible] growth. Am. Naturalist 17: [illegible] June, 19[illegible]

Gray, G. W. [illegible] growth. Scientific American, 1[illegible], [illegible] 19[illegible]

Shock, N.W. The physiology of aging. Scientific American, 206: 100-111, Jan. 1962.

[illegible], M. General Growth and Development. Prentice-Hall, Inc., Englewood Cliffs, N.J., 19[illegible]. pp. [illegible]

Other references

Comfort, A.: Ageing. The Biology of Senescence. Revised ed. Holt, Rinehart, and Winston, N.Y., 1964.

Dobzhansky, T.: Genetics of homeostasis and senility. In Genetic Concept for the Origin of Cancer. Ann. N.Y. Acad. Sci., 71: 1234-1241, 1958.

Tanner, J. M.: Growth at Adolescense. Springfield: C.C.Thomas, 1955. 212 pp.

Thompson, D'A. W.: On Growth and Form. N.Y.: Macmillan Co., 1942 pp. 78-285.

Strehler, B.L.: Time, Cells, and Ageing, Academic Press, N.Y., 1962.

Strehler, B. L. and Mildvan, A. S.: General theory of mortality and ageing. Science, 132: 14-21 (July 1) 1960.

Yapp, W. B., and Bourne, G.H.: The Biology of Ageing. Symp. Inst. Biol., London, No. 6. 1957.

Other references

Comfort, A.: Ageing, The Biology of Senescence. Revised ed. Holt, Rinehart and Winston, N.Y., 1964.

Dobzhansky, T.: Genetics of homeostasis and senility. In Genetic Concept for the Origin of Cancer. Ann. N.Y. Acad. Sci., 71: 1237-1241, 1958.

Tanner, J. M.: Growth at Adolescence. Springfield: C.C. Thomas, 1955. 212 pp.

Thompson, D'A. W.: On Growth and Form. N.Y.: Macmillan Co., 1942. pp. [illegible]

Strehler, B.L.: Time, Cells, and Aging. Academic Press, N.Y., 1962.

Strehler, B. L. and Mildvan, A. S.: General theory of mortality and ageing. Science, 132: 14-21 (July 1) 1960.

Yapp, W. B. and Bourne, G. H.: The Biology of Ageing. Symp. Inst. Biol., London, No. 6. 1957.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369
Physiology 369, Sociology 369, Veterinary Science 369, and
Zoology 369)

Lecture 7. Reproduction and Fertility in Mammalian Populations (Sargent)

Two sexes, the male and female, are partners in the diecious reproduction of mammals. Each is highly specialized morphologically, physiologically and psychologically to perform their respective roles in this complex process. The period of reproductive activity begins with maturity. The length of the reproductive period of a species is determined by the female, for she becomes anovulatory (ceases to produce ova) at the menarche; the male may exhibit active spermatogenesis long after the menarchial age of the female. Contributions to the gene pool of future generations can only be made during the reproductive period of the sexual partners of the species.

Reproduction begins with the fertilization of the egg or ovum from the female by sperm provided by the male. Among mammals fertilization occurs internally with the female who provides the fertilized egg with an aqueous environment for its subsequent development. Within the amnionic sac the ontogeny of the fetus recapitulates its marine phylogeny. The temperature of the amnion is closely regulated by homeothermic mechanisms of the mother at a temperature which assures rapid development. The fetus is nourished by the mother through the placenta and the newborn is nourished, again by mother, at the mammary glands.

Reproductive activity and reproductive efficiency are influenced by a spectrum of external and internal factors. Among some mammals olfactory stimuli not only signal the male that the female is receptive but also determine the regularity of the oestrus cycle and the success of mating. Many species of mammals are seasonal breeders; domesticated animals, including man, are "continuous" breeders but even these species exhibit seasonal variation in reproductive activity. The seasonal rhythm of reproduction may be related to the photoperiod. Internal factors influencing reproductive efficiency include neurohumoral feed-back mechanisms of the hypothalamo-pituitary-gonadal system, the rate of ovulation, the age of the female, the age of the gametes (ovum and sperm), and a "friendly" uterine environment. The nutrient regimen of the mother also determines the incidence of embryonic malformation and mortality.

Theoretically the sex ratio of a mammalian species should be 100 males per 100 females. The primary sex ratio (i.e., the ratio at conception) is not known but among humans and cattle the number of males among abortions may exceed the females by a factor of three or four. The secondary

INTRODUCTION TO HUMAN BIOLOGY
(Anthropology 200, Geography 200, Health Education 200,
Psychology 200, Sociology 200, [illegible] Science 200, and
[illegible])

Lecture 7 Reproduction and Fertility in [illegible] Populations (Harrison)

Two sexes, one male and one female, are partners in the effective reproduction of mammals. Each is highly specialised anatomically, physiologically and behaviourally to perform their respective roles in this complex process. The typical reproductive activities begin with courtship. The length of the reproductive period of a species is determined by the female, for she becomes [illegible] to produce eggs at the [illegible] into [illegible] after the menstruation in the female. Contributions to the gene pool of subsequent generations can only be made during the reproductive period of the female members of the species.

[illegible] the fertilisation of the egg [illegible] the female [illegible] for [illegible] sperm [illegible] the female [illegible] developing [illegible] and [illegible] development. [illegible] the [illegible] of the [illegible]. The [illegible] of the [illegible] by the [illegible] of [illegible] the [illegible] development. The form [illegible] and the [illegible] is [illegible] by [illegible].

[illegible] reproductive activity [illegible] a [illegible]. [illegible] the [illegible] of the [illegible] and the [illegible]. [illegible] a [illegible] and [illegible]. The [illegible] activity. The [illegible]. [illegible] of the [illegible], the age of the female, the age of the [illegible] and a [illegible]. The [illegible] of [illegible].

The [illegible] should be [illegible] per [illegible]. The [illegible] (e.g., [illegible]) [illegible] and [illegible] the number of [illegible] among [illegible] the [illegible] by a [illegible] of [illegible]. The [illegible]

sex ratio (i.e., ratio at birth) varies widely from 50 per cent for each sex. The evidence suggests that genetic factors, the condition of the uterine environment, and the frequency of sexual activity by the male are among processes which cause the sex ratio to deviate from 100/100 .

If fertility is defined as the capacity of sexual partners to produce normal and effective offspring, it follows that a great many exogenous and endogenous processes may modify this ability. The evolution of vivipary and homeothermy provided physiologically for the care of the conceptus. Parental care evolved as a behavioral process to support the survival of the offspring until they were capable of an independent existence and to train them in the traditions of the species. With the evolution of parental care, fewer offspring had to be produced in the reproductive period, reproductive efficiency increased, and more energy could be diverted from reproductive processes to other systems and functions.

The long post-reproductive period of civilized man probably is crucial not only in providing parental care for the slowly maturing children but in making possible transference of culture, an important element of cultüral evolution. Parents caring for offspring in a way that promotes their survival can be viewed as part of the breeding population. Williams (1957) suggests that actüally parents are not post-reproductive until the children are self-sufficient.

The human male exhibits a slow decline in reproduction. In the female it is abrupt. Williams (1957) makes the intriguing point that the menarche may have had selective advantage some time during human evolution. "Menopause, although apparently a cessation of reproduction, may have arisen as a reproductive adaptation to a life-cycle already characterized by senescence, unusual hazards in pregnancy and childbirth, and a long period of juvenile dependence. If so it is improper to regard menopause as a part of the ageing syndrome." (Williams, 1957, pp. 407-8).

Required Reading

Kendeigh, S. C.: Parental care and its evolution in birds. Ill. Biol. Monographs, Vol. 22, Nos. 1-3, 1952. pp. 298-302.

Nalbandov, A. V.: Reproductive Physiology. Comparative Reproductive Physiology of Domestic Animals, Laboratory Animals and Man. W. H. Freeman and Co., San Francisco, 1958, pp. 5-8; 66-73; 205-217, 246-266.

Other references

Lawrence, P.S.: The sex ratio, fertility, and ancestral longevity. Quart.Rev. Biol., 16: 35-79 (Mar.) 1941.

sex ratio (i.e., ratio at birth) varies widely from 5[illegible] per cent for each sex. The evidence suggests that genetic factors, the condition of the uterine environment, and the frequency of [illegible] by the [illegible] are among [illegible] which cause the sex ratio to deviate from 50 [illegible].

If fertility is defined as the capacity of sexual partners to produce normal and effective offspring, it follows that [illegible] many ontogenetic and endogenous processes must modify this ability. The evolution of viviparity and hormone therapy provides physiologically for the care of the conceptus. Parental care evolved as a behavioral process to insure the survival of the offspring until they are capable of an independent existence and to transmit to them the traditions of the species. With the evolution of parental care, fewer offspring [illegible] in the reproductive period, reproductive efficiency increased, and more energy could be diverted from reproductive processes to other systems and functions.

The long post-reproductive period of humans may probably be related not only to prolonging existence, caring for the slowly maturing children, thus making possible the transmission of culture, an important element of cultural evolution. [illegible], stepping in a way that promotes their [illegible], can be viewed as part of the learning situation. Williams (1957) suggests that [illegible] elderly parents [illegible].

The human male [illegible] no such post-reproductive period. In the absence [illegible] of [illegible] (Williams, 1957) [illegible] the [illegible] that the [illegible] advantage [illegible] human [illegible]. Women [illegible], although apparently [illegible] of reproduction, [illegible] as a separate [illegible] unusual [illegible] pregnancy and childbirth, and a long period of parental dependence. [illegible] syndrome" (Williams, 1957, pp. [illegible]).

Required Reading

Beadle[illegible], [illegible] C., [illegible] and [illegible] Proc. [illegible] Vol. [illegible], 1952, pp. [illegible].

[illegible], A. [illegible] Reproductive [illegible] [illegible] [illegible], 1958, pp. [illegible] 105-211, [illegible].

Other references

Lawrence, P. S., [illegible] Bull. [illegible], 1941.

Parks, A.S., and Bruce, H.M.: Olfactory stimuli in mammalian reproduction. Science, 134:1049-1054 (Oct. 13) 1961.

Williams, G.C.: Pleiotropy, natural selection, and evolution of senescence. Evolution, 11:398-411, 1957.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369,
Physiology 369, Sociology 369, Veterinary Science 369, and
Zoology 369)

Lecture 8. Organic Control Mechanisms: Genetics as Cybernetics (O'Kelly)

Until the advent of man, by far the most important mechanism of evolutionary change in brain systems was the device of genetic inheritance. Each generation of a given species manifests a wide range of trait variability and is subjected to selective pressure. To the extent that the trait variability is genetically linked, survival to a breeding age insures a statistical bias for preservation of that trait. Thus, it is useful to view genetic mechanisms as means for steering the development of species characteristics.

Concept of the "gene pool". The basic characteristics of organisms are derived from their chromosomal composition, the genes in complex fashion influencing the adaptational potentialities of any individual. Over-simplifying the matter in ways that will be mentioned in the lecture, we may assume that the totality of available genes for a given species form a "gene pool". Mating can then be viewed as sampling from the gene pool. Free "random" mating would then give, for each generation, a representative selection of all genetic determiners in the pool for that species, unless special circumstances would occur to bias the chance nature of the genetic lottery. It is, of course, precisely these biasing circumstances that are at the heart of the evolutionary process. Any circumstance that produces bias from randomness in the sampling in one generation will tend to change the population characteristics of the gene pool in the next generation.

<u>The evolutionary process of "natural selection."</u> While our knowledge of the means of evolution has progressed to the point that we can speak confidently of the fact of evolution, the basic points of Darwin's theory are still valid. To remind you, the steps in his argument may be summarized as follows:

1. production of offspring in excess of the number that can survive to a reproductive age.

2. offspring manifest variability in amount and kind of traits that contribute to survival.

3. the excess population leads to inter- and intra-species competition.

4. outcome of this competition is death of the less fit before achievement of reproductive age.

5. progeny of survivors tend to inherit parents' characteristics.

Modern additions to evolutionary theory come largely with reference to genetic mechanisms of variability. Darwin was always uncertain concerning the means of transmitting traits from one generation to another. For a time he leaned towards a Lamarkian inheritance of acquired characteristics, and he even tried his hand at a genetic theory based on the assumption of a blending of hereditary determiners. Mendelian insight for unit-character nature of inheritance, and DeVries' discovery of "spontaneous" changes in chromosomal or gene structure (mutation) puts the explanation of transmission and of the source of trait variability on firmer ground.

A variety of circumstances contribute to these basic ways of species modification. The following list is not exhaustive.

1. Isolation: gradual and relatively sudden or "catastrophic" geological changes serve to separate groups. By presenting different habitat conditions the criteria for successful adaptation may change. The biasing effect of mutations in the new separated gene pools can then steer development into different channels. Prevention of interbreeding between the isolates may preserve genetic peculiarities which would not have been emphasized in the total group. (See, Glass, H.G. The genetics of the Dunkers. Sci. Amer., 1953, 189, #2, 76-82).

2. Hybridization: Closely related species may be interfertile, and if they interbreed, the rather greatly changed gene pool may result in sufficiently biased selection to lead to new and variant species.

3. Migration: As Professor Shimkin has already mentioned, a variety of circumstances may operate to produce an altered range for a species, causing in turn new competitive circumstances and altering the criteria of survival. Here it is important to recognize that migration may be a critical factor not only for the incoming species, but for those whose habitat is invaded.

The temporal scale on which evolutionary development has taken place was covered in previous lectures. It is worthwhile, however, to again be reminded of the staggering truth that each one of us is alive because our own ancestors, back through unbroken generations for the past 2 billion years were well-adapted enough, and lucky enough, to live, each in his own generation, long enough to reproduce. What a collection of time-tested adaptive structures go into the makeup of any contemporary living system. However, all is not necessarily joyous in this contemplation. Our contemporary scene, species-wise, is a testimony to past successes. Our present structures (and thus functions) are only possible if they have been of positive adaptive significance (or irrelevant to survival). Structures of negative

adaptive significance do not last long. Selection, by and large, has been dependent on adequacy of regulatory mechanisms, as we saw in Dr. Sargent's lectures. But, since the screening criterion is always "past-oriented," operating on previous generations, we inherit the adaptations that were good for them--this may lead to adaptive failures in the screening criteria change (geologic, climatic or cultural changes, for example.) Rates of acquisition and disappearance of structures in species may be critical to species survival. Structural specialization can lead species into evolutionary blind alleys, and on the whole seems to have the effect of tailoring species for rather narrowly specific habitats. These structural adaptations are the key to the ecological composition of the life-space; the structure of an animal or plant dictates where it can live, and what associates it can have. We all know that catastrophes can result when this fact is overlooked (introduction of rabbit to Australia, lamprey eel to Great Lakes, English sparrow to U.S., etc.) Evolutionary adaptations and "genetic steering" go beyond and across species boundaries.

Required Reading

Huxley, J.: Evolution in Action. pp. 1-62.

Dobzhansky, Th.: Evolution, Genetics and Man. pp. 109-133.

Other references

Lack, D. Darwin's finches. Sci. Amer. 188 (4): 66-73, 1953.

Rand, McNally & Co. The histomap of evolution.

Reynold, H. C.: The opossum. Sci. Amer., 188 (6): 85-96, 1953.

Roe, A., & Simpson, G. G. (Eds.): Behavior and evolution. New Haven: Yale Univ. Press, 1958. pp. 27-75, 103-127.

Simpson, G.G.: The meaning of evolution. New Haven: Yale Univ. Press, 1950. (available as paper-back in abridged form. This is a modern classic of sorts, and should be in every biologist's library).

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 9. Organic Control Mechanisms: Basic Processes of External Regulation (O'Kelly)

Professor Sargent's presentation of homeostatic mechanisms showed living systems maintaining steady states by internal structural and functional adaptations. Most homeostatic mechanisms operate by means of transformations and exchanges of substances between internal components of the system. Homeostatic processes cannot continue to maintain steady states indefinitely, however, without means of renewing basic materials. Maintenance of steady states requires energy, and thus demands inputs of energy-rich materials and outputs of waste products.

Thus, along with internal regulation, the survival of the system depends on it coming into contact with sources of input which will make up for the deficiencies or the excesses which have accumulated as a result of homeostatic functioning. Here we get the emergence of behavior. If there was a free flow of materials into the cell, and out from the cell, there would be no behavior, no need to react differentially with respect to different parts of the environment. Some living creatures approximate this sessile state, and most of those that do are in a marine habitat. The organism living in an heterogenous environment must be able to achieve capacity to move from place to place in order to contact his sources of supply.

The development of animals has been critically influenced by the heterogenous distribution of materials in their habitats. One of the most basic features of multicellular forms, the differentiation of limiting membranes to form an internal aqueous buffer region between the cells and the external world, was forced by the lack of uniform correct conditions for maintenance of cellular life. The evolutionary pressures that push organisms into an ever wider variety of habitats are matched by the structural-functional specializations that shield them threats to their steady states. This reaches a most dramatic peak in man in, for example, his elaboration of space capsules as a sort of outer shell that mimics the integument in its protective function.

Both external and internal regulation are possible by structural adaptations. In the suggestions for a model of regulation which follow it should be remembered that the distinction between internal and external can frequently be artificial and arbitrary, or in fact, at some stages of regulation, may not exist.

INTRODUCTION TO [illegible]

[illegible] 1[illegible], [illegible], [illegible],
[illegible], [illegible], [illegible] Science [illegible] and
[illegible]

Lecture 3. [illegible] Part I. [illegible] of [illegible]
[illegible]

Professor [illegible] presentation of [illegible] defined [illegible] organizing [illegible] and [illegible] functional [illegible] of many [illegible] between [illegible] of the [illegible] However, [illegible] of [illegible] simply [illegible] and [illegible] of [illegible] and control of [illegible].

Thus, [illegible] organization, [illegible] on it [illegible] will make [illegible] differences in the [illegible] which [illegible] and [illegible] functioning. [illegible] of materials into the cell, and out from the cell, there would be no [illegible] we find [illegible] different parts of [illegible] that do [illegible]. The [illegible] order to [illegible].

The development of [illegible] has been [illegible] influenced by the heterogeneous distribution of materials in [illegible]. One of the most [illegible] the differentiation of [illegible] region between the [illegible] water, [illegible]. The [illegible] that [illegible] of habitats [illegible] by the [illegible] special[illegible] that [illegible] them [illegible]. This [illegible] a most [illegible], for example, [illegible] as [illegible].

[illegible] and [illegible] regulation [illegible] by [illegible] in the [illegible] for [illegible] of [illegible] which [illegible] between [illegible] and [illegible] artificial and [illegible], or in fact, at some stages of [illegible], may not exist.

Stimulus → Detector → Searching and Orientation → Corrective Behavior → Satiety

Feedback

The problem of detector systems. A "self-regulating" system must be able to detect a degree or amount of accumulating deficiency or excess that is threatening to its steady state. A variety of structures within organisms function as "imbalance detectors." They must be thought of as working in a fashion similar to sense organs, i.e., they must be sensitive to some particular index of the condition they safeguard, they must have differential thresholds, to distinguish between large and small departures, and must be capable of originating signals communicable to the corrective apparatus of the body. Physiological and (to a lesser extent) anatomical evidence identifies such detector systems for plasma concentration (index of dehydration), body temperature changes, blood glucose level, CO_2 tension of blood, etc. Organisms are not ideal with respect to their inventory of detectors since there are many requirements for steady state constants for which no detector systems exist, e.g., nutritional need for trace elements and vitamins. If no detector system exists there is obviously no way that organisms can orient themselves appropriately, even if the required substance exists in their environment. Also, as examples to be cited in lecture show, it is possible for organisms to behave in such a fashion as to override or ignore detector signals.

The problem of orientation or search systems. A regulatory system must contain a provision for instigating the organism to search through the possibilities of its environment and to orient it with respect to a needed state of affairs. Thus, a hungry animal must be able to differentially seek out and orient towards foods, a thirsty animal towards water, etc. The neurological mechanisms responsible are difficult to stipulate, probably because so much of behavior is involved here. What the psychologist calls "perception memory," "attention" are all manifested in this orienting behavior. Research has been directed towards identification by the experimenter of specific cue-need relationships. What qualities of water differentiate it from food? What characteristics of closely related species serve to identify appropriate and inappropriate mating partners? Finally, there is an important question of the relative contribution of genetically determined and learned mechanisms, both of which seem to be invariably involved. (Salmon return to fresh water to spawn, a genetically stable discriminatory pattern, but appear to learn the stimulus cue patterns necessary to insure return to their native spawning ground.)

The third component of a regulatory model would be a provision for correctional behavior. These components seem to be very stable structural

Stimulus → Detector → Assembly → Corrective → Stable
Response

The problem of [illegible] ... system must be able to detect a departure [illegible] ... That is, according to [illegible] ... organisms function as "comparator mechanisms." [illegible] ... sense organs, [illegible]. Response is sensitive [illegible] ... between large and small [illegible] ... of [illegible] ... [illegible]

The problem of [illegible]. A regulatory system must contain a [illegible] for [illegible] the organism to search through [illegible] of its environment [illegible] to a [illegible] of things. Thus, [illegible] differentially [illegible] ... animal [illegible]. The [illegible] mechanisms [illegible] are difficult to [illegible] ... The psychologist's [illegible] "perception," "attention" [illegible] in [illegible] behavior. Research has been [illegible] ... relationships. What [illegible]? What [illegible] to identify [illegible] systems? Finally, there is an important question of [illegible] genetically determined and learned [illegible] which seem to be invariably [illegible]. [illegible] genetically stable [illegible] patterns [illegible].

The third component of a regulatory model would be [illegible] behavior. These components seem to be very stable [illegible]

adaptations, and comprise the functions which actually restore the steady state, such as eating, drinking, urination, copulation, shivering, sweating, respiring, etc.) However, considerable elaboration of correctional behavior by learning is possible. (Example: urination and defecation among sociological adults in our culture. Actual consummatory response is a primitive reflex, but necessary preliminaries highly modified by learning.) It is important to recognize that orientation and correction are interactive, as is well illustrated in phenomena of prefe rence behavior; hungry animals will make selection of more "palatable" over less palatable food, even at sacrifice of caloric value.

Finally, a regulatory system must make provision for detection of satiety, a mechanism for terminating correctional action when the steady state is restored. Requirements are similar to those for the need detector system as sketched above, and in many cases the satiety may be detected by simple removal of the circumstances which stimulated the detector component in the first place. Other instances point to specifically different mechanisms for satiety detection than simple subsidance of signals in the need detector component. (Example: an animal stops drinking water before ingested water can be distributed to cells whose dehydration initiated the drinking sequence.) Some satiety systems, because of the lags in metabolic transport, have an anticipatory function, "predicting" restoration of the steady state. Much of satiety detection involves states of afferent conduction from "stretch receptors" in hollow-walled organs, such as stomach, intestine, bladder, rectum, etc.

Required Reading

von Bertelanffy, L.: The theory of open systems in physica and biology. Science, 111: 23-29, 1950.

Other r eferences

Adolph, E. F.: Physiology of Man in the Desert. New York: Interscience Press, 1947.

Adolph, E. F.: Physiological Regulations, Lancaster, Pa., Cattel, 1943. 453-469.

excitation, and compare the functions of the [illegible] motor systems of the [illegible] [illegible]

Finally, [illegible] physiology [illegible] [illegible]

Required Reading

von Bertalanffy, L. "The theory of open systems in physics and biology." Science, 111: 23-29, 1950.

Collateral Reading

Adolph, E. F. Physiology of Man in the Desert. New York: Interscience, 1947.

Adolph, E. F. Physiological [illegible], [illegible], 1943. 283-[illegible]

INTRODUCTION TO HUMAN ECOLOGY

(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 10. Organic Control Mechanisms: Integration and Control in Higher Animals (O'Kelly)

The preceding lecture dealt with organic control systems in their most general form. Today we will consider some aspects of such systems as we find them operating in vertebrate forms. In the higher mammals particularly, steady state maintenance becomes inseparable from a number of complex behavior patterns.

Two aspects of external regulation must be explained: (a) an energizing component, and (b) a directional component. Consider an animal in a completely steady state with respect to all of its metabolic requirements. External, as well as internal, regulatory demands are at a minimum, and similarly, behavior would be also minimal. (Such an animal, and such a state, is of course purely hypothetical). However, as Kleitman has demonstrated, the sleeping animal approaches such a state. Let us start our analysis by considering the problem of sleep and waking.

Following Kleitman, we can assume that sleep is the natural condition of the animal, and that the basic problem is to explain wakefulness. He shows that the primitive or very young animal is awake only when disturbed by internal or external disequilibrating circumstances, that is, when it is hungry, thirsty, cold, wet, in pain. At all other times it is asleep. The wakefulness then, in his terminology, is of necessity, and the over-all sleep pattern is polyphasic, its rhythm being determined by the combined waxing and waning of deficiencies and excesses. For very primitive forms the tides of activity and passivity are of the polyphasic type throughout the life cycle. In the higher animals, however, there is an ontogenetic development or transition from the wakefulness of necessity to what Kleitman calls (rather unfortunately) wakefulness of choice. Here the animal is awake and active in growing independence of basic homeostatic status, and learned patterns of sleep-waking displace the primitive polyphasic; in man, quite generally, the "wakefulness of choice" leads to a diphasic sleep rhythm, with many cultural as well as physiological determinants of its time distribution within the 24-hr. period.

The structural equipment responsible for maintaining the animal in a waking or sleeping state is becoming increasingly well known, and it is also becoming obvious that the neurological mechanisms underlying these states

are also responsible for, or provide the investigator with some glimpses of, the basic integration scheme underlying all behavior. Let us start by noting a useful index of neural activity in relation to the sleep-waking continuum: the electroencephalogram (EEG). The brain manifests a continuous rythmical electrical activity which may be detected, amplified and recorded from electrodes placed on the surface of the scalp. The EEG frequency and amplitude characteristics are related, in an orderly fashion, to the degree of behavioral alertness of the subject. The frequency continuum of the EEG ranges from very slow (1/2-2/sec.) waves in deep sleep and coma, through 10/sec. activity in a state of relaxed inattention, to 30-40/sec. in states of active arousal of attention. Amplitude is inversely related to frequency.

In the preceding lecture we noted that the detector systems, like all sensory structures, must perform the dual function of transmitting specific information and making a contribution to a generalized alerting. Anatomically, two great afferent neural systems can be differentiated with respect to this dual function. All sense organs originate messages that are carried by the specific projection systems to circumscribed areas of the brain, each area corresponding closely to a particular sensory surface. Thus we have visual and auditory and cutaneous receptors, and corresponding areas of the brain. The informational aspect of environmental signals is carried into the central nervous system via this specific system. In addition, each specific afferent tract gives off collaterals that feed into a non-specific or diffuse afferent system, in which excitation from all sensory sources is mingled; this system then projects diffusely to most areas of the cerebral cortex, and performs a generalized alerting function. The alerting is relatively independent of the specific informational content of the environmental signal. It can be detected by the EEG, where "desynchronization" or a shift from 10/sec. to 20-40/sec. activity denotes the alerting function. The major anatomical tract responsible for carrying the diffuse excitation is the reticular formation of the brain stem, and it is commonly referred to in the trade as the ascending reticular activating system (ARAS). Some of the evidence for the functional role of this system, and its importance to organic regulation will be given in lecture.

In the hypothalamus (small, centrally located region of brain at the base of the cerebrum), are located many of the structures which serve as detectors, lying in intimate association with blood vessels, and generally neural or neurosecretory in function. In addition, the hypothalamus contains areas which seem to be critical for maintenance of both the sleep and waking state. It may be assumed that the energizing effects of steady state departures are mediated through the combined action of the detector regions and the sleep and waking "centers."

Still further insight for mammalian organic control comes from the discovery that animals will actively work to receive electrical stimulation in a number of areas of their brains. These areas, promptly dubbed "pleasure centers" have the property of reinforcing the behavior which led to their

stimulation. While it is still too early to hazard more than a guess as to the role they might play in the intact animal it is probable that they are part of the mechanism that aids the animal to maintain his orientation towards needed environmental substances.

To briefly summarize the material covered in these three lectures, we have seen that the survival requirements of living systems have, by providing criteria of structural adequacy, given direction to development, and that the mechanisms so evolved furnish an important part of the equipment through which all forms of behavior are mediated. In all vertebrates these mechanisms can be "captured" by the individual modifications in brain function that come about through the capacity of the organism to learn. Later developments in the course will be concerned with some of the extraordinary large number of ways that organic control mechanisms for system survival can work themselves out in both biological and social settings.

Required Reading

Olds, James. Pleasure centers in the brain. Sci. Amer. Oct., 1956.
French, J. D. The reticular formation. Sci. Amer., May, 1957.

Other references

Ellingson, R. J.: Brain waves and the problems of psychology. Psychol. Bull., 53: 1-34, 1956.
Kleitman, N.: Sleep and Wakefulness. Chicago: Univ. Chicago Press, Revised ed., 1963.
Lindsley, D. B.: Psychological phenomena and the electroencephalogram. EEG clin. Neurophysiol., 4: 443-456, 1952.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Environments, Organisms and Communities: Introduction to Lectures 11 to 15 (Shimkin)

This course began with attempts to define the basic hypotheses and methods of human ecology. It then sought to characterize one major set of ecological variables--the environment--as a system of physico-chemical conditions and relations which evolved in a highly specialized form as a consequence of geological, climatic and biological events since the Cretaceous. The contemporary terrestrial environment is, furthermore, differentiated regionally by forces varying in type and intensity largely with latitude, altitude and degree of continentality.

Organisms comprise a second set of ecological variables. All life has in common a series of physico-chemical processes which can only be carried on in aqueous solution, and in the presence of narrowly variable chemical concentrations, temperatures and pressures. This necessary homeostasis is thermodynamically unstable and depends upon continued captures of external energy to maintain a structure and an iterative cycle of activities, known as the steady state. In multicellular animals, the steady state also must be considered as an iterative succession of generations: the life sequence provides a mechanism for minimizing cumulative random mutations by periodic replacements of unadaptive, aged individuals, and by reducing reproductive capacity to a limited period of high physiological efficiency. The life sequence and sexual reproduction transform organic adaptations into social processes, in which role differentiation, cooperation, and genetic intermixture compound the primary biological activities of homeostasis, mutation and death.

At all levels, from the intra-cellular to those of complex societies, organic adaptations are time-directed, or cybernetic, phenomena. All biological events, including all human activity, comprise resultants of two forces: past activity incorporated in a memory and released, or fed back as inputs into subsequent events; and disbalances in synchronous forces. These disbalances arise from external changes, cyclical homeostatic events and, in multicellular animals, irreversible life sequences. The cybernetic mechanisms are complex at all levels, involving digital and analog operations, time sensing, time-space (Fourrier) transformations, etc. (v. Neumann). They include intro-cellular systems (chromosomal and other), central systems (especially the central nervous system in vertebrates), and social systems. The most fundamental of the last, up to the rise of linguistic transmission, has been genetics. In particular, departures from randomness in breeding, induced

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369,
Physiology 369, Sociology 369, Veterinary Science 369, and
Zoology 369)

Environments, Organisms and Communities -- Introduction to Lectures 11 to 15
(Shimkin)

This course began with an attempt to define the basic hypotheses and methods of human ecology. It then sought to characterize one major set of ecological variables--the environment--as a system of physico-chemical conditions and processes which evolved in a highly specified form as a consequence of geological, climatic and biological events since the Cretaceous. The contemporary terrestrial environments, furthermore, differentiate regionally by forces varying in type and intensity largely with latitude, altitude and degree of continentality.

Organisms constitute a second set of ecological variables. All life has in common a series of physico-chemical processes which can only be carried on in aqueous solution, and in the presence of narrowly suitable chemical concentrations, temperatures and pressures. This necessary homeostasis is thermodynamically unstable and depends upon continual inputs of external energy to maintain a structure and an iterative cycle of activities, known as the steady state. In multicellular animals, the steady state is [illegible] ordered as an iterative succession of generations: the life sequence, provides a mechanism for [illegible] cumulative evolution by genetic replacements of inadequate, aged individuals, and by restricting reproductive moments to a limited period of high developmental efficiency. The life sequence and sexual reproduction transform organic adaptations into social processes, in which role differentiation, cooperation, and genetic intermixture [illegible] the primary biological activities of homeostasis, mutation and death.

At all levels, from the intra-cellular to those of complex societies, organic adaptations are goal-directed, or cybernetic, phenomena. All biological events, including all human activity, comprise resultants of two forces: past activity incorporated in a memory and released, or fed back, as inputs into subsequent events, and disturbances in synchronous inputs. These disturbances arise from external changes, yielding immediate stress, and, in restricted later moments, irreversible life sequences. The cybernetic mechanisms are numerous, at all levels, involving digital and analog operations, time scanning, time-space [illegible] transformations, etc. [illegible]. They include intra-cellular systems (chromosomal and other), control systems (especially the central nervous system of vertebrates), and social systems. The most fundamental of the last, up to the rise of symbolic transmission, has been genetics. In particular, departures from randomness in breeding, induced

by geographical or social isolation, lead to systematic differentiations in gene frequencies and, hence, in derived characteristics.

In today's world, organisms occur only in a community of varied species as well as of varied individuals. The relations between species and populations are complexly functional, particularly in relation to the food chain. Hence, the third dimension of ecology is the biological community which Professor Kendeigh will discuss in Lectures 11-15. Here again many processes and relations, both external and self-regulating will be visible once more, but in a new context of increasing complexity.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 11. The Biotic Community (Kendeigh)

An understanding of animal ecology is important--the ecology of animals is also the ecology of man. There is nothing unique in the relations of man to his environment that does not occur, in at least a rudimentary manner, in the relations of animals to their environment.

A community or biocenose is a unit aggregation of organisms consisting of a distinctive combination of species. The habitat is a specific set of physical conditions that surround a species or a community. The ecosystem is a particular biotic community and its habitat.

Organisms vary in importance in the community in respect to their restriction, abundance, seasonal occurrence, societies, and influence. Dominants are the most important organisms. They determine the composition and character of the community, receive the full impact of the climate or habitat, and establish the physical conditions under which other organisms must live (reactions). Or they exert dominance by direct attack on other species (coactions).

Plants are generally dominant on land. Each principal type of vegetation contains a distinctive aggregation of animal species. Each species of plant and animal plays a particular role in the life of the community as a consequence of the ecological niche that it occupies. There is thus a division of labor, the culmination of a long-time evolutionary development through the animal kingdom.

Animal species occur in particular communities and habitats because of morphological adaptations, physiological adjustments, behavioral responses and community interrelations.

Leibig's law of the minimum states that the functioning or occurrence of an organism is limited by that essential environmental factor or combination of factors present to the least favorable extent.

When subjected to a gradient of intensities of an environmental factor, either experimentally or in Nature, animals show a preferendum, being most abundant or comfortable in the intermediate or optimum situation and become

[illegible]

[illegible] 13. The Plant Community (continued)

[illegible] There is [illegible]

A community [illegible] is a [illegible] of [illegible] ing a distinctive combination of species. The [illegible] is a specific set of physical conditions that [illegible] a species or a community. The ecosystem is a [illegible] community and its habitat.

[illegible] in importance in the community [illegible] abundance, dominance, frequency, occurrence, sociation and [illegible]. Dominants are the most important organisms. They [illegible] of the community [illegible] and especially the physical conditions under which other organisms [illegible]

[illegible]

[illegible] of morphological adaptations, physiological adjustments, behavioral responses and [illegible]

[illegible]

[illegible]

less abundant or more uncomfortable toward each extreme of the factor until they disappear altogether. The normal or Gaussian curve is of utmost significance in understanding animal activity and distribution.

Readings in Kendeigh's Animal Ecology

Required	Supplementary
Pages 6-21, 26-30	Chapter 9

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 12. Succession, Climaxes and Biomes (Kendeigh)

Succession is the replacement of one community by another. This may be brought about by (a) evolution, dispersal, extinction; (b) changes in the earth's surface; (c) changes in climate; (d) reactions and coactions of organisms themselves.

Succession proceeds until a climax community is reached. The concept of climax is most useful for the biosere. Seres developing on rock, clay soil, floodplains, or in ponds have different plant stages, but convergence of all bioseres takes place to the same climax community.

The reactions of organisms that bring about succession involve: (1) stabilization of substratum; (2) adding humus to increase fertility; (3) improving moisture content of soil; (4) decreasing light intensity. The coactions involve invasion of new communities of species and extirpation of old communities--a complex process.

The nature of the climax depends on the climate. There is a general world-wide agreement between types of vegetation, climate, and soil. These major climax biotic communities are biomes. The seral communities are immature or developmental stages of the biome. The biome represents a distributional unit of major importance for analyzing the intimate relations of animals to their environment on a geographical scale. The major biomes are the temperate deciduous forest, coniferous forest, woodland and chaparral, tundra, grassland, desert, tropical forest and tropical savanna. The distribution and activities of primitive man were intimately related to these biomes.

Readings in Kendeigh's *Animal Ecology*

Required	Supplementary
pages 21-26, 105-112	Chapter 8
276-279, 284-291	Chapters 22-27

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 13. Origin, Dispersal, Speciation, and the Ecological Niche (Kendeigh)

By dispersal we mean the outward spread without return of individuals from their homesites. This dispersal is primarily by young animals or immature stages and takes place largely because of population pressure (competition) in their home areas. Dispersal takes place in all directions until stopped by barriers. These may be physiographic, climatic, or biotic.

The center of origin of most major animal groups is supposed to have been the oriental tropics. Dispersal from here has been over land bridges to other parts of the world. Once having dispersed, populations may become geographically isolated. This leads to speciation.

Speciation is the process of evolutionary differentiation between populations which may result in one species becoming split into two or more new ones.

A species is a group of populations capable of successful interbreeding and which are reproductively isolated under natural conditions from other such populations. If interbreeding regularly occurs between adjacent populations, although they differ in various characteristics, they are considered as races or subspecies.

Geographic isolation allows independent variation and difference in natural selection to occur with the development of reproductive isolating mechanisms, which in increasing order of effectiveness are ecological, ethological, and mechanical or genetic.

Such geographic isolation has permitted the evolution of the great faunas of the zoological regions of the world. Each region in turn may be subdivided into faunal areas or communities (biociations) distinctive in genera and species of animals.

With speciation there is nearly always a divergence into a different ecological niche from that of the parent species. The ecological niche includes both the microhabitat to which the species is adapted and the relations which it establishes with other species occurring in the same community. Segregation of species into different niches results from competition, and, once established and becoming inherited, reduces competition between them.

INTRODUCTION TO ANIMAL ECOLOGY
(Anthropology [illegible], Biogeography [illegible], Health Education [illegible],
Physiology [illegible], Sociology [illegible], Veterinary Science [illegible], and
Zoology [illegible])

Lecture [illegible]. Origin, Dispersal, Speciation, and the Ecological Niche
(Kendeigh)

By dispersal we mean the outward spread without return of individuals from their homesites. This dispersal is primarily by young animals or immature stages and takes place largely because of population pressure (competition) in the home areas. Dispersal takes place in all directions until stopped by barriers. These may be physiographic, climatic, or biotic.

The center of origin of most major animal groups is supposed to have been the equatorial tropics. Dispersal from here has been to the far edges in other parts of the world. Once having dispersed, populations may become geographically isolated. This leads to speciation.

Speciation is the process of evolutionary differentiation between populations which may result in one species being changed into two or more new ones.

A species is a group of populations capable of successful interbreeding and which are reproductively isolated under natural conditions from other such populations. If interbreeding regularly occurs between adjacent populations, although they differ in various characteristics, they are considered as races or subspecies.

Geographic isolation allows independent variation and difference in natural selection to occur with the development of reproductive isolating mechanisms, which in increasing order of effectiveness are ecological, ethological, and mechanical or genetic.

Such geographic isolation has permitted the evolution of the great faunas of the zoological regions of the world. Each region in turn may be subdivided into faunal areas or communities (biotic regions) distinctive in genera and species of animals.

With speciation there is nearly always a divergence into a different ecological niche from that of the parent species. The ecological niche includes both the microhabitat to which the species is adapted and the relations it has established with other species occurring in the same community. Segregation of species into different niches results from competition, and, once established and becoming inherited, reduces competition between them.

According to the competitive exclusion principle (Gause's rule) an ecological niche cannot be simultaneously and completely occupied by stabilized populations of more than one species. Niches may differ in many ways: often very slight differences may be sufficient to permit two species to occur in the same community or in adjacent communities: adaptations to physical factors of substratum, type of vegetation or cover required, stratum of vegetation used, time of day active, season of year active, food.

Readings in Kendeigh's Animal Ecology

Required	Supplementary
pages 145-156, 257-260, 245-254.	pages 255-276

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 14. Nutrient Cycles, Food Chains, and Population Dynamics (Kendeigh)

In general, animals consume a wide variety of food species, providing it is of a certain type. Some selection is made depending on its nutritional value, palatability, size, protective devices, but especially on its availability.

One species of animal may feed upon another but ultimately they must feed on plants so that food chains are formed. Dozens of food chains may occur in the same community, involving the same and different species, so that a complex food web is formed. The food web may be simplified by grouping all species with similar feeding relations into the same trophic level: producers; primary, secondary, tertiary, and quaternary consumers; transformers.

Species in the lower consumer levels are usually of smaller size, greater numbers, have higher rates of reproduction, and are of greater diversity than those in higher trophic levels.

The relation between size and numbers is well shown by the pyramid of numbers. There are always a larger number of small animals in a community than of large ones. The relation of abundance to trophic level is also well shown by a pyramid made up of the biomass of each level. The ratio of biomasses from one level to the next higher is commonly 5:1. The maintenance of numbers or biomass of the different trophic levels in more or less constant ratios with each other indicates that under natural conditions there is a balance of nature.

Since plants absorb nutrient materials, such as nitrogen or phosphorus, from the soil and carbon dioxide from the air in order to photosynthesize food, and since animals must consume plants to get their food or consume one another, and since all organisms decompose when they die to release nitrogen, phosphorus, carbon, and other elements that can then be reabsorbed by plants, there is continual cycling of nutrient materials through the ecosystem.

In seral stages, nitrogen-fixation exceeds denitrification, so there is progressive increase in the fertility of the soil. In climax communities, the relative number of legumes carrying nitrogen-fixing bacteria is reduced so the cycle is often balanced and the ecosystem is in a steady state.

Readings in Kendeigh's Animal Ecology

Required	Supplementary
Chapter 13	Chapter 11

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 15. Energy Flows and Productivity (Kendeigh)

The cycling of nutrients and activities of organisms require energy. The amount of work accomplished depends on the amount of energy available. The source of all energy is the sun. The efficiency of photosynthesis is low, usually less than 1%, although somewhat higher with cultivated crops. Gross primary productivity is lowest in deserts and semi-deserts, but increasingly higher in communities with denser vegetation, and highest in some aquatic and forest communities.

Energy is transferred from one trophic level to another by predation, but considerable is lost at each trophic level, partly through excretion of indigestible material, wastage from kills, and non-predatory deaths. This energy, however, is still available to the transformers in the soil and may again be taken up by higher trophic levels feeding on bacteria and detritus. Energy is converted into work or lost as heat to the atmosphere at each trophic level, so it does not circulate as do nutrients; it flows through the ecosystem and must be replaced continuously.

Crops of game animals, plants or trees, or food, removed by man from the ecosystem, represent a yield. Yield is highest if taken at the lower levels. The ratio of productivity between trophic levels is roughly 5:1. When a yield is taken out of an ecosystem, one removes not only energy but also minerals. Energy can be quickly replaced if a good stand of green plants is left, but replacement of minerals is slow.

Food, space, and climate, constitute the ultimate limiting factors on the population size attained by any species. All populations increase in size at a rate corresponding to a sigmoid growth curve. The reproductive or biotic potential of population growth is exponential but is seldom realized in nature because of environmental resistance. Absolute growth rate is most rapid at the point of inflection; beyond this point, inhibiting factors progressively slow up rate until it becomes stabilized at an asymptote. Density-stabilizing factors must be density-dependent, varying in intensity with the size of the population. These are competition, reproductivity, predation, emigration, and disease. Different species become stabilized at different population levels, dependent on their requirements for food, space, and favorable climate. These latter limiting factors are density-independent.

[illegible]

[illegible]

The [illegible]. The amount [illegible]. The [illegible] primarily [illegible] [illegible].

[illegible] energy, however, [illegible].

[illegible]

[illegible]

Any population may be increased in size when the influence of the density-stabilizing factors is reduced and the limits set by space and food are raised. For obtaining maximum sustained yield from any species of economic importance, the size of the yield or harvest should be regulated to keep the population level at the point of inflection on the growth curve.

Readings in Kendeigh's *Animal Ecology*

Required	Supplementary
Chapters 14, 16	Chapters 15, 17, pages 159-162

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 16. The Evolution of Homo sapiens (Sargent)

The creature customarily identified as MAN is classified taxonomically in the Order of Primates, in the Suborder Anthropoidea, in the Superfamily Hominoidea, and in the Genus Homo. There is only one species of modern man, Homo sapiens. The fossil evidence demonstrates that the Order of Primates has existed for some 75 million years. Homo sapiens appears to have been present for not more than 50 thousand years, or about 2,000 generations.

The evolutionary trends which are peculiar to the Order of Primates include (1) preservation of generalized structure of limbs and limb skeleton, (2) enhancement of free mobility of digits, (3) development of digits with flattened nails and sensitive tactile pads, (4) progressive reduction of snout, (5) perfection of visual apparatus, (6) reduction of the effectiveness of the olfactory apparatus, (7) simplification of dentition, (8) progressive expansion and elaboration of the brain, particularly the cerebral cortex, and (9) development of an increasingly efficient apparatus for nourishing the fetus. These trends together with a lack of structural and functional specialization are probably the consequences of living in an arboreal ecological niche.

The evolutionary history of the hominoids which modern anthropologists have pieced together is most incomplete, for a continuum of emergence of Homo from primitive hominoids cannot be convincingly demonstrated from the fossil evidence so far discovered. The main features of the probable evolutionary continuum, however, seem to be established, many of the events can be dated with reasonable accuracy, and the paleo-ecological setting for this emergence can be described. There is now overwhelming evidence that culture played a dominant role in man's adaptive radiation from the hominoids.

About one million years ago, late in the Pliocene epoch or early in the Pleistocene epoch, the taxonomic lines identified as the family Hominidae and the family Pongidae emerged from a common hominoid ancester. This development, according to current evidence, took place in East Africa. Australopithecus was a bipedal hominid of the Lower Pleistocene, who lived in open grassland not unlike modern South Africa. His hands were free and he probably used implements of stone and bone for hunting small animals and the young of large species to supplement a primarily vegetal diet. His brain capacity was between 450 and 600 cc. The acquisition of bipedalism and the

[illegible]
[illegible]
[illegible]
[illegible]

Section II. [illegible]

The [illegible] of the Order of Primates [illegible]. There are only [illegible] [illegible] [illegible] than 50 thousand years [illegible] [illegible].

The [illegible] (2) [illegible] (3) [illegible] (4) [illegible] (5) [illegible] (6) [illegible] [illegible] and [illegible] of the brain [illegible] [illegible].

The [illegible] [illegible] [illegible]. The [illegible] [illegible] [illegible].

[illegible] years ago [illegible] Pleistocene [illegible] [illegible] [illegible] [illegible].

[illegible]

use of implements exerted selective pressures which led to expanded brains. In the middle Pleistocene, 125 to 250 thousand years ago, Pithecanthropus appeared. He occupied the same ecological niche as Australopithecus and appears to have eliminated him. Geographical conditions favored the wide dispersal of Pithecanthropus and his remains have been discovered in southeastern Asia and southwestern Europe. He had a locomotor skeleton remarkably similar to Homo; his brain had a capacity of 900-1100 cc. He exhibited great technological advances in the manufacture of stone implements and seems to have discovered fire. The major glaciations of the Middle Pleistocene not only favored dispersal of this hominid but also brought about geographical isolation. Large scale interbreeding was prevented and regionally distinctive cultural and technological traditions developed. There were also marked morphological differences in the various skeletons of Pithecanthropus. Whether these regional differences in skeletal remains and cultural artifacts represent a beginning of human speciation promoted by geographical barriers or merely the inherent variability within the peoples of that time cannot be decided from the evidence now in hand.

Further technological advances and ground living and hunting exerted additional selection pressures for larger brains. When Homo sapiens emerged some 35 to 50 thousand years ago, during the middle of the last glaciation of Pleistocene, the brain capacity had reached 1200-1500 cc, a value not dissimilar to that of the modern representatives of the species. Homo sapiens spread widely and rapidly over Europe and Asia and soon surmounted all geographical barriers to become one large interbreeding population. Because of man's mobility and gregariousness, speciation would appear to be unlikely. The question of continuing evolution of man is a topic of current debate (Hulse).

Required reading

Le Gros Clark, W. E.: The crucial evidence for human evolution. American Scientist, 47: 299-313 (September) 1959.

Washburn, S. L.: Tools and human evolution. Scientific American, 203: 62-75 (September) 1960.

Other references

Bartholomew, G.A., Jr., and Birdsell, J. B.: Ecology and the Protohominids American Anthropologist, 55: 481-498, 1953

Bordes, F.: Mousterian cultures in France. Science, 134: 803-810 (September 22) 1961.

Daniel, G. E.: The idea of man's antiquity. Scientific American, 201: 167-176 (November) 1959.

[illegible]

[illegible]

Essential Reading

[illegible]

[illegible]

Other references

[illegible]

[illegible]

[illegible]

Dobzhansky, T.: Mankind Evolving. Yale Univ. Press, New Haven, 1962.

Emiliani, C.: Dating human evolution. In The Evolution of Man (Sol Tax, ed.) Evolution after Darwin. Vol. II. Univ. of Chicago Press, Chicago, 1960.

Hackett, C. F. and Ascher, R.: The human revolution. Am. Scientist, 52: 70-92, 1964.

Howell, F. C.: The Villafranchian and human origins. Science, 130: 831-844 (October 2) 1959.

Hulse, F. S.: The Human Species. Random House, N.Y., 1963.

Kulp, J. L.: Geologic time scale. Science, 133: 1105-1114 (April 14) 1961.

Le Gros Clark, W. E.: The Antecedents of Man. An Introduction to the Evolution of the Primates. Quadrangle Books, Chicago, 1961. 374 p.

Scriven, M.: Explanation and prediction in evolutionary theory. Science, 130: 477-482 (August 28) 1959.

Simons, E.L.: New fossil primates: a review of the past decade. American Scientist, 48: 179-182 (June) 1960.

Washburn, S. L., and Howell, F. C.: Human evolution and culture. In The Evolution of Man (Sol. Tax, ed.) Evolution after Darwin. Vol. II, Univ. of Chicago Press, Chicago, 1960. pp. 33-56.

INTRODUCTION TO HUMAN ECOLOGY

(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 17. General biological characteristics of Homo sapiens (Sargent)

Man is a primate. He exhibits the biological traits of this order of mammals. Whereas the evolution of mammals has been characterized by somatic specialization and progressive adaptation, primates have been distinguished for their lack of specialization and progressive adaptability.

Genotypic fitness is both a function of the organism and of the environment. Fitness can only be judged in terms of the capacity of the organism to survive in a particular environment or in a range of environments. The capacity to survive develops in two ways. (1) Genetic diversification leads to environmental specialization, i.e. adaptation to a specific environment or to a limited range of environments. (2) Genetical controlled adaptive plasticity of the phenotype leads to fitness for survival in a wide variety of habitats, . . i.e. adaptability or broad norm of reaction.

Genotypic fitness is the result of processes not conditions. The internal environment is not inherited. The physiological mechanisms which permit the organism to react to environmental circumstances so as to preserve the internal environment are inherited. This view is what is implied by the idea of the genetics of homeostasis (Lerner). By natural selection the useful regulations tend to survive.

The greater the variety of environments which a species encounters, the greater will be the fitness of the genotypes which make the development of organs and functions autonomous and independent of the environment (Dobzhansky, 1956). This process has been called stabilizing selection (Schmalhausen). Stabilizing selections makes the organism homeostatic.

Inborn differences among animals and among men are exhibited as polymorphic variation (e.g. sex and heterozygosity), metrical or polygenetic inheritance, genetically controlled adaptive plasticity of the phenotype, and molecular and metabolic diseases. Genetic diversification in man is the basis of biotypes.

Human biology is not merely an extension of the principles of animal biology to man. From the strictly biological viewpoint man possesses few characteristics which can be identified as unique. To be sure, he can be distinguished anatomically. Functionally, however, human beings differ

INTRODUCTION TO HUMAN BIOLOGY

[illegible] Dobzhansky [illegible],
[illegible] 1962 [illegible],
[illegible]

Lecture 17. Genetic background to the evolution of Homo sapiens (Dobzhansky)

Man is a primate. In general, the biological traits of the order of mammals [illegible] whereas the evolution of mammals has been characterized by specific specialization and progressive adaptation, primates have been distinguished by their lack of specialization and progressive adaptability.

Adaptation [illegible] a function of the organism and of the environment. [illegible] can only be judged in terms of the capacity of the organism to survive in a particular environment or in a range of environments. The capacity [illegible] (a) Genetic specialization [illegible] environment [illegible] i.e., adaptation to a specific environment or to a limited range of environments. (b) [illegible] adaptive plasticity of the phenotype [illegible] i.e., adaptability to a broad range of [illegible].

[illegible] internal environment [illegible] the organism [illegible] the internal environment [illegible] the idea of [illegible] to survive.

The greater the variety of environments which a species encounters, the greater [illegible] the development of [illegible] independence of the environment [illegible] selection [illegible].

Inborn differences [illegible] and among men are exhibited as [illegible] polygenic [illegible] plasticity of the phenotype, and [illegible] genetic diversification in man is the basis of [illegible].

Human biology is not [illegible] an extension of the principles of animal biology to man [illegible] characteristics which [illegible] unique [illegible] distinguished [illegible]

from other animals more in degree than in kind. We may then ask, as does Medawar (1957), what are the differences between other animals and man? Medawar (1957, p. 138) concludes that "man is unique among animals because of the tremendous weight that tradition has come to have in providing for the continuity, from generation to generation, of the properties to which he owes his biological fitness." Tradition and culture are synonymous in this context. Indeed, culture has become so much a part of man that it is difficult to separate it from his biology (Dobzhansky, 1962).

Organisms demonstrate "biological fitness" if they are endowed with organs, systems and processes which enable them to sustain themselves in and prevail over their environments (Medawar, 1957). For man there are in-born endowments and the technological creations of his culture. Both have exhibited evolution, but cultural evolution has been the more rapid (Blum, 1963). Both contribute to his biological fitness. Medawar (1957, p. 142) views tradition (or culture) as "a biological instrument by means of which human beings conserve, propagate and enlarge upon those properties to which they owe their present biological fitness and their hope of becoming fitter still."

Biological fitness is greater among organisms that are adaptable than among those that are adapted. Man is adaptable. His adaptability arises from his genetic individuality, his phenotypic plasticity, and his culture. Each human being is a unique combination of genetic traits. One individual is anatomically and functionally, with the exception of monozygous twins, unlike any other (Medawar, 1957). This inborn diversity and the genetical system responsible for maintaining that diversity allows selection to happen with the result that evolution proceeds. The important selective forces in the environment are weather and climate, food and water shortage, predation, and disease.

Since there is a diversity of genotypes controlling these homeostatic mechanisms, one finds that the characteristics of the internal environment and of physiological regulations exhibit an inter-individual variability which suggests that they arise from polygenetic inheritance. Evidence for this concept has been reviewed by R. J. Williams and will be illustrated with observations of F. Sargent on biochemical and physiological properties of the blood and on the functioning of major organs and systems among 200 young men. Man's individuality must be carefully considered in cultural ecological concepts which, in the past, have tended to treat him as a statistical unit.

Adaptability is not only a consequence of morphological, functional and behavioral plasticity (phenotypic changes) but also of the environment. Adaptability can only be thought of meaningfully in an environmental context. The adaptability of the human genotypes must be judged in terms of an ability for survival in four general environmental types: the material environment, the biotic environment, the cultural environment, and the conceptual environment. In this lecture we shall discuss some aspects of human adaptability in the

from other animals more in degree than in kind. We may then ask, as does Medawar (1957), what are the differences between other animals and man? Medawar (1957, p. 139) concludes that "man is unique among animals because of the tremendous weight that tradition has come to have in providing for the continuity, from generation to generation, of the properties to which he owes his biological fitness." Tradition and culture are synonymous in this context. Indeed, culture has become so much a part of man that it is difficult to separate it from his biology (Dobzhansky, 1962).

Organisms demonstrate "biological fitness" if they are endowed with organs, systems and processes which enable them to sustain themselves in and prevail over their environments (Medawar, 1957). For man these are in-born endosomatic organs and the technological creations of his culture. Both have exhibited evolution, but cultural evolution has been the more rapid (Bloom, 1963). Both contribute to his biological fitness. Medawar (1957, p. 142) views tradition (or culture) as "a biological instrument by means of which human beings conserve, propagate and enlarge upon those properties to which they owe their present biological fitness and their hope of becoming fitter still."

Biological fitness is greater among organisms that are adaptable than among those that are adapted. Man is adaptable. His adaptability arises from his genetic individuality, his phenotypic plasticity, and his culture. Each human being is a unique combination of genetic traits. One individual is anatomically and functionally, with the exception of monozygous twins, unlike any other (Medawar, 1957). This inborn diversity and the genetical system responsible for maintaining that diversity allows selection to happen with the result that evolution proceeds. The important selective forces in the environment are weather and climate, food and water shortage, predation, and disease.

Since there is a diversity of genotypes controlling the homeostatic mechanisms, one finds that the characteristics of the internal environment and of physiological regulations exhibit a large individual variability which suggests that they arise from polygenic inheritance. Evidence for this concept has been presented by R. J. Williams and will be illustrated with observations of E. Sargent on biochemical and physiological properties of the blood and on the functioning of organs systems and systems among 200 sports men. Man's individuality must be carefully considered in cultural ecological concepts which, in the past, have tended to treat him as a statistical unit.

Adaptability is not only a consequence of morphological, functional and behavioral plasticity (phenotypic changes) but also of the environment. Adaptability can only be judged meaningfully in an environmental context. The adaptability of the human genotypes must be judged in terms of the ability to survive and reproduce in each of the many environments: the biological environment, the cultural environment, and the conceptual environment. In this lecture we shall discuss some aspects of human adaptability in the

material and biotic environments. In the next lecture, aspects of human adaptability in the cultural and conceptual environment will be discussed.

The material environment shall be viewed as synonymous with the atmospheric environment. In regard to his adaptability to the atmospheric environment, one of man's biological weaknesses is uncovered. Man's heritage limits his functional capacity to adjust to wide variations in atmospheric temperature. Man is a tropical animal. He has a high and narrow "zone of thermal neutrality." Only between 23 and 33° C can naked man maintain a relatively constant rectal temperature with minimal levels of metabolism. The zone of thermal neutrality for the monkey, another tropical animal, is even narrower--28 - 30° C. On the other hand, the Arctic huskie can maintain his rectal temperature without elevating his metabolic rate from +30° to -40° C. Man can acclimate to hot atmospheres but he has only limited ability to acclimate to cold. Man's dispersal from his tropical center of origin has been accomplished far more through the use of acquired technological skills than through physiological processes.

It is from the biotic environment that man obtains the energy and matter required to meet his daily nutrient requirements. Man is primarily an omnivore, for he satisfies his nutritional needs from both plant and animal sources. In meeting his nutritional needs he exhibits considerable adaptability. Some men can subsist on a diet which is derived largely from animal foods and others subsist on vegetarian diets. Man can also adapt to undernutrition and his capacity to function during semistarvation is remarkable among the warm-blooded animals.

Many of man's diseases arise from the microbial organisms of the biotic environment. Man, however, has the capacity to adapt to these infectious agents through the production of antibodies. These gamma-globulins are produced by genetically controlled reactions with the cells of the lymphatic and reticulo-endothial systems. These antibodies counteract invading organisms and when the defense reaction is successful, the human has acquired an immunity to subsequent invasions by the particular species of microbe.

Required Reading

Williams, R. J.: Chemical anthropology--an open door. Am. Scientist, 46: 1-23, 1958.

Other references

Blum, H. F.: On the origin and evolution of human culture. Am. Scientist, 51: 32-47, 1963.

Dobzhansky, T.: The biological basis of human freedom. Columbia U. Press, N.W., 1956.

material and bodily adjustments. In the next lecture, aspects of human adaptability in the cultural and conceptual environment will be discussed.

The biotic environment shall be viewed as something within the atmospheric environment. In relation to the physical aspects of the atmospheric environment, one of man's biological weaknesses is temperature. Man's heritage from his Paleolithic ancestors is adjustment to a tropical atmospheric temperature. Man is a tropical animal. His is a high and narrow "zone of thermal neutrality." Only between 27 and 29° C can naked man maintain a relatively constant metabolism with minimal levels of metabolism. The zone of thermal neutrality for the monkey, another tropical animal, is even narrower, 28 - 30° C. On the other hand, the Arctic husky can maintain a normal temperature without increasing his metabolic rate from 20° to -40° C. Man can acclimatize to hot atmospheres but he has only limited ability to acclimatize to cold. Man's dispersal from his tropical center of origin has been accomplished far more through the use of acquired technological skills than through physiological processes.

It is man's biotic environment that provides him energy and matter to meet his daily nutrient requirements. Man is primarily an omnivore, for he satisfies his nutritional needs from both plant and animal sources. In meeting his nutritional needs he exhibits considerable adaptability, as is seen in the habits of Eskimos, whose diet is derived largely from animal foods and others who subsist on vegetarian diets. Man can also adapt to malnutrition and his capacity to function during semistarvation is pronounced among the warm-blooded animals.

Many of man's diseases come from the microscopic organisms of the biotic environment. Man, however, has the capacity to adapt to these infectious agents through the production of antibodies. These gamma-globulins are produced by a specifically organized reaction with the proteins of the invading and infecting microorganisms. These antibodies counteract invading organisms and when the defense reaction is successful, the man has acquired an immunity to subsequent invasions by the particular species of microbe.

Required Reading

Williams, R. J.: Chemical anthropology--an open door. Am. Scientist, 46: 1-23, 1958.

Other References

Blum, H. F.: On the origin and evolution of human culture. Am. Scientist, 51: 32-47, 1963.

Dobzhansky, T.: The biological basis of human freedom. Columbia U. Press, N.Y., 1956.

Medawar, P.B.: The Uniqueness of the Individual. Methuen, London, 1957.

Medawar, P. B.: The Future of Man. Basic Books, N.Y., 1960.

Williams, R. J.: Biochemical Individuality. The Basis for the Genetotropic Concept. John Wiley and Sons, Inc., N.Y., 1956. Paperback Ed.1963.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 18. Psychoneurological Specializations in Man (Sargent)

Human evolution has been both endosomatic (biological) and exosomatic (cultural). Exosomatic evolution is Lamarkian for cultural traits are acquired or learned traits. At the same time, the evidence from anthropological research demonstrates convincingly that culture created selection pressures which led to remarkably rapid growth of the human brain.

Distinctive characteristics of Homo sapiens are (1) his capacity for symbolic thought, (2) his use of language and writing in communication, (3) his technological skill in modifying the material and biotic environments and in utilizing both inorganic and organic constituents of these environments, (4) his extensive division of labor, and (5) his capacity to modify human behavior. The manifestations of these characteristics comprise the cultural environment. The system which has supported the development of culture has been the brain and the nervous system.

The history of the human brain extends over more than 400,000,000 years. The major evolutionary changes which have led to the development of the brain and nervous system of Homo sapiens have been the enlargement of the cerebral cortex, the perfection of the visual apparatus, the reduction of the olfactory apparatus, and the development of the reticular (integrating) and lemniscal (affector-effector) systems.

In mammals the cerebral cortex consists of the paleocortex, archicortex, and neocortex. The paleocortex and archicortex together comprise the rhinencephalon or smell brain and are present in all vertebrates. The basic functions of the rhinencephalon are smell, emotion, and regulation of visceral function. The neocortex first appeared in reptiles but became the dominant part of the cortex in mammals, particularly primates and man. As the neocortex enlarged, the smell brain decreased and many sensory and motor functions were encephalized. The enlargement of the cortex was accomplished by folding of brain mass and increase in size and number of nerve cells. The major functions which have encephalized have been psychic and associational ones associated with the frontal lobes. The visual sense has moved from the midbrain to the occipital cortex. The olfactory sense has become less acute.

A well-developed visual sense is an important primate characteristic. The importance of this sense for man is indicated in the fact that the neurons of the optic nerve constitute more than one-third of all the neurons entering and leaving the central nervous system. The crossing-over of the neurons from nasal retina and the non-crossing of neurons from the temporal retina seems to be an adaptive radiation associated with frontality of the eyes. This

Lecture 12. [illegible]

Human evolution has been both endosomatic (biological) and exosomatic (cultural). In some respects evolution is a separation for cultural traits are acquired or learned traits. At the same time, the evidence from anthropological research (fossil brains) demonstrates that culture created selection pressures which led to remarkably rapid growth of the human brain.

Distinctive characteristics of Homo sapiens are (1) his capacity for symbolic thought, (2) his use of language and writing in communication, (3) his technological skill in modifying the material and biotic environments and in utilizing both inorganic and organic constituents of these environments, (4) his extensive division of labor, and (5) his capacity to modify his own behavior. The manifestations of these characteristics comprise the cultural environment. The system which has supported the development of culture has been the brain and the nervous system.

The history of the human brain extends over more than 500,000,000 years. The major evolutionary changes which have led to the development of the brain and nervous system to Homo sapiens have included the enlargement of the cerebral cortex, the specialization of the visual apparatus, the reduction of the olfactory apparatus, and the development of the reticular (integrating) and the visceral (afferent-effector) systems.

In mammals the cerebral cortex consists of the paleocortex, archicortex, and neocortex. The paleocortex and archicortex together comprise the rhinencephalon or smell brain and are present in all vertebrates. The basic functions of the rhinencephalon are smell, emotion, and regulation of visceral function. The neocortex first appeared in reptiles but became the dominant part of the cortex in mammals, particularly primates and man. As the neocortex enlarged, the smell brain decreased and many sensory and motor functions were localized. The enlargement of the cortex was accomplished by folding of brain mass and increase in size and number of convolutions. The major functions which have been emphasized have been motility and [illegible] associated with the visual sense. The visual sense has moved from the midbrain to the occipital cortex. The olfactory sense has become less acute.

A well-developed visual sense is an important primate characteristic. The importance of this sense for man is indicated in the fact that the neurons of the optic nerve constitute more than one-third of all the neurons entering and leaving the central nervous system. The crossing-over of the neurons from nasal retina and the non-crossing of neurons from the temporal retina seems to be an adaptive relation associated with mobility of the eyes. This

phylogenetical development together with encephalization of the visual sense made binocular vision possible.

The development of the lemniscal systems, particularly the pyramidal system, made possible coordinated movements and fine manual dexterity--another primate trait. The development of the reticular system played an important part in this motor evolution, for it is an important integrative mechanism in behavior.

With the development of the neocortex has come the capacity to facilitate and inhibit the functions of more primitive parts of the nervous system, the capacity to remember, and the capacity to make symbolic abstractions and communicate pragmatic non-expressive material. Cultural traditions can be acquired and enlarged by man's educability.

Within the mind of each man there develops a concept of himself in relation to his particular culture. This conceptual environment is symbolic and mystical yet very real. When there is no individual conflict between the conceptual and cultural environment, the person enjoys mental health. When a conflict arises, mental disease is the consequence.

Required Reading

Nobach, C. R.: The Heritage of the Human Brain. American Museum of Natural History, New York, 1959. 30 p.

Other references

Hackett, C. F., and Ascher, R.: The human revolution. Am. Scientist, 52: 70-92, 1964.

Huxley, J. S.: Man Stands Alone. Harper, N.Y., 1941. (The uniqueness of Man, pp. 1-32).

Lassek, A. M.: The Human Brain. C. C. Thomas, Springfield, 1957.

Menninger, K.: The Vital Balance. Viking, N.Y., 1963.

Penfield, W.: The interpretive cortex. Science, 129: 1719-1725 (June 26) 1959.

Pfeiffer, J.: The Human Brain. Harper & Bros., New York, 1955, pp 1-104. (A readable semitechnical treatment which makes perusing valuable).

EXAMINATION PERIOD

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 20. The Mechanisms and Institutions of Human Socialization (Shimkin)

Man is a large, slowly maturing and rather weak forest-edge primate. Omnivorous habits, resistance to starvation; an ability to run, climb and swim; good sight and hearing; high manual dexterity; great learning ability, and--above all--an extreme socialization permitted by flexible, efficient communication represent his major biological assets. Man's socialization has much in common with that of other animals, but is unique in the range of behavior controlled, in the variety of roles distinguished, in the complexity of the social structures engendered, and in its capacity for adaptive development.

1. Socialization as an evolutionary force. The advent of sexual reproduction and of other behavioral cooperation in food procurement, mutual protection against predators and the environment, and in the care of the young profoundly modified the effects of individual mutation and survival as evolutionary forces. In societies, as opposed to unstructured populations, competition is both limited and intensified; territorial, age and other groupings emerge as partial or complete reproducing isolates. Role specialization permits fuller use of the habitat, while sharing and sexual reproduction mean more complete consumption and biological transfer of available food. In particular, sexual dimorphism and other reiterated variants conserved by the society change the mathematics of selection. Bounded, polymodal distributions replace normal distributions for the corresponding variables. Instead of independent probabilities, there are now conditional probabilities, dependent upon some least survival of every indispensable role in the society. At the same time, time-dependent self-correcting devices emerge. For example, constant male-female ratios characterize each new generation regardless of the anomalies in sex ratios brought upon the parent generation--up to the destruction of one sex, and total extinction. Thus societies are far more resilient than were aggregates. Finally, because societies offset individual weaknesses or limitations by cooperation, they are far less affected by Liebig's Law of the Minimum than are unstructured groups.

2. Mechanics of human socialization. All living cultures, and perhaps all cultures since the time of Neanderthal man, are characterized by extensive and efficient systems of socialization. These embody two aspects: the socialization of each generation, and the preservation of social norms. In essence, socialization involves the extension of a common system of external regulation from individual organisms to all members of a group.

INTRODUCTION TO HUMAN ECOLOGY

(Anthropology 2[illegible]0, Geography 2[illegible]0, Health Education [illegible], Physiology 305, Sociology 260, Veterinary Science [illegible], and Zoology [illegible])

Lecture 20. The Mechanisms and Institutions of Human Socialization (Continued)

Man is a large, slowly maturing and relatively weak forest-edge primate. Omnivorous diets, resistance to starvation; no ability to run, climb and swim; good sight and hearing; high manual dexterity; great learning ability, and -- above all -- an extreme socialization permitted by the [illegible] sufficient communication equipment [illegible] his major biological assets. Man's socialization has much in common with that of other animals, but is unique in the range of behavior controlled, in the variety of roles differentiated, in the complexity of the social structures engendered, and in its capacity for adaptive development.

1. Socialization is an evolutionary force. The advantages of frequent reproduction and of other behavior of cooperation in food procurement, mutual protection against predators and the environment, and in the care of the young profoundly modified the effects of individual mutation and survival of [illegible] mutants. In societies, as opposed to unstructured populations, competition is both limited and intensified, controlled. Age and other groupings emerge as partial or complete reproducing isolates. Role specialization permits fuller use of the habitat, while sharing and mutual reproduction makes more complete consumption and biological transfer of available food. In particular, special [illegible] and other unrelated variants preserved by the society change the mechanics of selection. Bounded, polymodal distributions replace [illegible] distributions for the corresponding variables. Instead of independent mechanisms, there are now conditional probabilities, dependent upon some kind of a very indispensable one in the society. At the same time, direct independent self-correcting devices emerge. [illegible] constant [illegible] each new generation [illegible] of the mortality [illegible] brought upon the parent generation -- up to the destruction of one sex, and total extinction. Thus societies are far more resilient than are aggregates. Finally, because societies offset individual weaknesses and limitations by cooperation, they are far less affected by Liebig's law of the minimum than are unstructured groups.

2. Mechanisms of human socialization. All living cultures, and perhaps all cultures since the time of Neanderthal man, are characterized by extensive and efficient systems of socialization. These embody two aspects: the socialization of each generation, and the preservation of social forms. In essence, socialization involves the existence of a complex system of transferring information from individual organisms to all members of a group.

In man, this complex task involves six phenomena:

a. Play, or self-stimulation, which develops basic cognitions, releases somatic tensions, and develops habits of experimentation.

b. Inhibition by parental or other discipline, which induces value dichotomies (yes-no, good-bad), a recognition of role differences and, through managed frustrations, enhanced symbolization. All societies inhibit basic drives by limitations upon sexual activity, especially the universal prohibition of intercourse between parents and children; by restraints upon aggression; and by strong pressures toward food sharing. Inhibited drives are socially controlled through the displacement of emotional objects, through the internalization of responses, and through the development of substitute satisfactions.

c. Orientation, or the orderly structuring of perceptions, which seems to involve a successive discrimination of persons (self, mother, man, etc.); of states (hunger, thirst, etc.); of animals and things; and, finally, of relationships (space, number, time, etc.). This rationalization, which removes the "contamination of field and image" observed among young childrenby Piaget, takes place in all cultures, but is strongly influenced in detail by language and other cultural categories (Carroll-Casagrande).

d. Reciprocal communication through efficient speech, a universal human trait, which includes the capacity to express subjective states and induce empathic reactions (as among chimpanzees), but also to replicate preceptions through exposition, and to elicit desired actions through commands or pleas.

e. Patterning, which transforms learned behavior into reliable, quickly initiated yet flexible systems of action. Patterning involves a conceptual standardization of categories and relationships, a reduction of random variations, and increasingly free utilization of the range of combinations permitted by the pattern, e.g. a multiplication table.

f. Code extension, which means successive adaptation to new roles by appropriate learning, the partial suppression of old behavior (e.g., infant speech) and finally the achievement of a new integration, with added capacities for code (or role) switching.

Socialization is a difficult set of processes, which every human group consciously promotes through reinforcement by response, guidance and sanction. This begins in early infancy; by six months, babies' babblings are no longer random but approximations cf adult phonemes. In pre-literate cultures, the problem of code standardization is acute, particularly wherever small communities and short life expectancies limit training possibilities. Patterning and emotional reinforcement through coding in verse and song,

and through religious associations often help reinforce memories and preserve norms.

3. The institutions of socialization.

All known human socialization develops with a context of functional structures, social codes and modal interaction patterns which is in part common to all cultures and in part distinctive for each. Some such distinctions are directly adaptive, e.g. as reflections of different population sizes and densities, and others are conventional yet important as symbols of identity.

a. Functional structures. Simple, face-to-face communities composed of families and homogeneous associations comprise the totality of many societies and the basic constituents of all. Families are universal units of approved sexual activity, nurture and consumption; they also have varying degrees of productive and regulatory functions. Asymmetrical roles, with differences in permitted behavior, authority and responsibility are inherent, and often reinforced by religious sanctions. Families vary greatly in type, and include nuclear, reduced, extended; macro-families (lineages, phratries); and those augmented by fictional kin (adoptions, godparental kin). variations in descent (patriliny, matriliny, bilaterality), in stability of marriage, in residence patterns, in spouse and parent-child statuses, and in the degree of reinforcement by property relations induce much operational variation.

Homogeneous associations, the formal or informal groupings of age-mates, often of the same sex, are the essential action groups of every society for play, work, religion, warfare, etc. They are characterized by uniform orientation, largely parallel or reciprocal roles, clear in-group and out-group symbols, and corporate existence despite rapid changes in membership.

Families and homogeneous associations combine roles and activities into minimal communities which, among some impoverished cultures such as the Alacaluf of southern South America, meet only periodically. Regulation through assent, status reinforcement, and circular interactions and exchanges of goods, services and members within the simple community constitute its basic functions in all cultures, from hunters to urbanites. Other basic characteristics include a locus and a territory; more rarely, names and other symbols of identity.

Larger social aggregations will be discussed in Lecture 22, under socio-cultural evolution.

b. Social codes. All societies depend upon systems of rules which permit communication, define goals (regulation by emulation), set bounds (regulation by sanction), and formulate paradigms for cooperation. Languages,

kinship systems, ceremonial and monetary exchange systems, and legal codes exemplify such systems. All social codes are characterized by five features: (1) Bodies of underlying social theory including doctrinal foundations (religion, mythology, proverbs, etc.) as sources of authority, and replicable rules of application (if: then...). (2) Systems of reinforcement by teaching and reward. (3) External and internalized sanctions, especially ridicule (e.g. by "joking relations"), supernatural intervention, ostracism and expulsion, physical punishment and guilt, often with severe psychosomatic consequences (hysterias). (4) Graduated levels of application, as illustrated by discriminations of responsibility and competence, intent, etc. (5) Incomplete logical consistency, as real systems rather than formal, canonical ones.

c. Modal interaction patterns. Basic differences between socializing contexts arise from variations in the frequency distributions and, hence, the probabilities of specific types of interactions in given communities. Knowledge of these probabilities results in corresponding anticipations, rationales and courses of action. In general, interaction patterns can be characterized in terms of eight features: (1) Periodicity (irregular, periodic, continuous); (2) Patterning (random to categorical); (3) Concentration (diffused to focused); (4) Mediation (direct relations to multi-stage ones); (5) Trajectories (reciprocal, circular, or uniderectional flows); (6) Efficiency (from reverberatory interactions to absorbing ones, with no return); (7) Automaticity (unconditional versus conditional interactions); and (8) Stability (overtime, or in physical or social space). In all cultures some interactions exhibit each of these characteristics but the modal frequencies vary. Although much more needs to be done in this area, it is clear, for example, from Lévi-Strauss' pioneering work that the automatic, circular exchange systems of western Pacific cultures have profoundly different ecological dynamics from the conditional, absorbing systems favored by western laissez faire economics. One promotes minimum welfare for a maximum population; the other, selective welfare and maximum resource accumulation. One is current-time oriented; the other, future-time directed.

Required Reading

V. G. Childe: "Early forms of society," in Singer et al I: 38-57.

Other References

S. H. Bartley: Principles of Perception. Harper & Bro. New York, 1958 (esp. pp. 22-95).

J. B. Carroll and J. B. Casagrande: "The function of language classifications in behavior," in E. E. Maccoby et al: Readings in Social Psychology 3d ed. N.Y.: Henry Holt & Co., 1958.

kinship systems, ceremonial and monetary exchange systems), and must always exemplify such systems. All social events are [illegible]. (2) Systems of underlying social theory [illegible] theoretical foundations (religion, mythology, [illegible], etc.) [illegible], and [illegible] modes of application (cf. [illegible].) (c) Processes of maintenance by [illegible] and [illegible]. (3) Personal and internalized knowledge, [illegible] (e.g. by "kinship relations"), supplementary [illegible] and computation, physical punishment, [illegible] consequences [illegible]. (4) Generalized modes of operation, as [illegible] or discriminations of responsibility and [illegible], etc. (5) [illegible] logical consistency, of the system [illegible] ones.

c. [illegible]. [illegible] socializing contexts arise from [illegible], hence, the probabilities of specific types of [illegible]. Knowledge of these probabilities [illegible] patterns and contexts of behavior. In general, [illegible] characterized in terms of eight features: (1) [illegible], periodic, continuous; (2) [illegible]; (3) [illegible] (related to [illegible]); (4) [illegible]. (5) Trajectories (reciprocal, circular, [illegible]). (6) [illegible]. (7) [illegible] (unconditional) [illegible], or in physical or social space. [illegible] which each of these [illegible]. Much more needs to be done [illegible]. Levi-Strauss' pioneering work [illegible] of [illegible] static [illegible] from [illegible] [illegible]. The [illegible] other, [illegible] these concepts [illegible].

Required Reading

1. G. [illegible], "[illegible]" [illegible].

Collateral Reading

3. R. [illegible], [illegible]. Harper & Row, New York [illegible]. [illegible]

4. [illegible] Carroll and [illegible], "[illegible] of Language [illegible]" in [illegible] (ed.) [illegible], 3d ed., [illegible], [illegible].

C. Levi-Strauss: Les Structures Elementaires de la Parente (The Elemental Structures of Kinship) Paris: Presses Universitaires de France, 1949 (esp. pp. 35-86, 524-591).

J. H. Steward: Theory of Culture Change. Urbana: University of Illinois Press, 1955. (esp. pp. 101-172).

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 21. Human Utilization of the Natural Environment (Shimkin)

A major fruit of man's socialization, which evolved as early as the Upper Paleolithic and which appears to be a common property of all living cultures, is a distinctive strategy for exploiting the natural environment. The cumulative effects of applying this strategy have developed new capacities in man and forced him into commitments of effort which have characterized the bulk of all cultures. Common problems and limited numbers of alternative solutions have been persistent forces toward cultural parallelism, convergence and diffusion. Nevertheless, no known society is fully pragmatic and stereotyped; conversely, expressive behavior and innovations in all societies are continually finding pragmatic use and becoming patterned. The essence of socio-cultural evolution is a dynamic balancing between the forces of change and of stabilization in increasingly larger, better equipped and better integrated societies.

1. The strategy of human environmental use. Six components embody this complex:

a. Economic organization, which involves a division of labor through specialization and cooperation; the recognition of equities, or property rights, for current, past or potential services; the exchange of goods and services between individuals and groups; and the regulation of demand, production and distribution in accord with the community's social codes. Specialization and cooperation within the family are pre-human; however, Upper Paleolithic hunting for the mammoth, horse and reindeer with the surrounding demanded new levels of organization, discipline and coordinated effort. Since sites for surrounds were limited and had to be free of human smell to be effective, concepts of trespass on group property arose. Ethnological data indicate that among the simplest cultures individual property includes personal things and incorporeal rights, e.g. magical songs and fetishes endowing the possessor with hunting luck, curative powers, etc. The latter reinforce role differences; at the same time, the prospect of their transfer by ceremony or at death gives them economic value in old age. In general, the span of private property increases with social complexity, but is always limited within in-groups. Special institutions--work groups, firms and bureaucracies--also develop in complex societies to perform given tasks and hold appropriate properties.

Lecture 21. Human Utilization of the Natural Environment ([illegible])

A major trait of man's socialization, which evolved as early as the Upper Paleolithic and which appears to be a common property of all living cultures, is a cooperative strategy for exploiting the natural environment. The cumulative effects of applying this strategy have developed new tendencies in man and forced him into organizations which have characterized the bulk of all societies. Common problems and limited numbers of alternative solutions have often permitted forces toward cultural parallelism, convergence and diffusion. Nevertheless, no known society is fully cooperative and stereotyped; conversely, cooperative behavior and innovations in all societies are constantly finding new [illegible] and becoming patterned. The essence of sociocultural evolution is a dynamic relationship between the forces of change and of stabilization; the more highly integrated, better equipped and better integrated societies.

1. *The strategy of human environmental use.* Its components include, this complex:

a. *Economic organization*, which involves a division of labor through specialization and cooperation, the recognition of individual property rights, the exchange of [illegible] services, the exchange of goods and services between individuals and groups, and the regulation of demand, production and distribution in accord with the community's social needs. Specialization and cooperation within the family are pre-human; however, Upper Paleolithic hunters of the mammoth, horse and reindeer who, surrounding the animals, had new levels of organization, discipline and cooperated effort. Since sites for such animals were limited and had to be [illegible] to be effective, concepts of trespass on private property arose. Ethnological data indicate that among the simplest cultures property includes personal things and incorporeal rights, e.g., magical songs and [illegible] obtaining the rights with hunting and [illegible]. The latter reinforce [illegible] differences at the same time, the prospect of [illegible] transfer by ceremony at death gives them some value in old age. In general, the types of property vary in proportion with social complexity and is always limited within the society. Specialization—craft guilds, agents and bureaucracies—also develop in complex societies to produce, distribute, and hold appropriate properties.

Exchanges may be distinguished as automatic, always within a closed group, e.g. primitive food distribution and modern social-security payments; and conditional, upon effecting some desired exchange (in goods, services or status) from unspecified sources. Freely accessible assemblies of persons and goods, or markets, and general codes of equivalence, or money, facilitate conditional exchanges. The relative returns, or terms of trade, in exchanges provide basic measures of social dominance; however, since relative scarcities (and related values) differ between individuals and groups, the terms of trade are multi-valued, and may be simultaneously favorable (or unfavorable) for both exchangers. The most effective exchanges offer credit at interest. They thus include anticipation, feedback and evaluation of risks.

Regulation of consumption, production and demand is universal. The formation of consumption units via cohabitation is restricted by incest taboos; by requirements of prior service, property exchange, and ceremony; and by supernatural and physical sanctions. This may effectively limit reproduction where, as in Tibet and Ireland, institutionalized celibacy has religious reinforcement . Another fertility-inhibiting pattern is found in Near Eastern urban cultures by polygany among the aged, with prostitution and homosexuality being recognized gratifications for younger males. Conversely, societies with strong inhibitions of homosexuality, with premarital license, and with systematically equalized economic returns, such as the Russian peasantry prior to World War II, maximize fertility, even survival is selectively regulated; both infanticide and the exposure of the aged regulated population among such Arctic peoples as the Chukchi and the Eskimo. Infanticide and abortion are old, widespread and effective means of regulating population size found in primitive, peasant and urban cultures: Polynesia, rural Bulgaria, Japan, Hungary, Sweden, etc. Often, as in Japan and Hungary, half or more of all conceptions are aborted. Private property accumulation, sharp status differences, and social mobility promote population limitation in all known cultures. Finally, other types of demands are also socially influenced, in both level and kind. This plasticity of demand, whether self-induced or externally enforced, represents one of man's fundamental adaptive assets.

b. Tools and instruments. The former move, shape and chemically transform matter.They also comprise containers such as baskets and pots, insulators and allied modifiers. Organisms, such as yeast or cattle, can be tools. Instruments extend perception and logical span, insure reliability of action, and economize efforts by feeding back past experience. Linguistic concepts of category, of time, space and number, and of logical relations underlie the systematic, socialized use of tools and instruments. Identifiable traditions of tool working date back to the Middle Paleolithic.

c. The systematic harvesting of foodstuffs and materials. Orderly observations, an epistemology of things useful and noxious, mobility,

Exchanges may be distinguished as automatic (always within a stored domain, e.g. patterned food distribution and modern social security payments) and conditional, when effecting some desired exchange of goods, services, or [illegible] from other sources. Freely accessible [illegible] of payment and contracts, [illegible], and prevalent codes of equivalence, or money, facilitate conditional exchanges. The relative returns, or terms of trade, in exchanges are [illegible] determined by values (which may be diverse since relative scarcities and desired values) differ between individuals and groups. The [illegible] is [illegible] valued, and may be simultaneously favourable (or unfavourable) for both counterparts. The main situations of exchange [illegible]. They [illegible] include contribution, feeding and [illegible] of goods.

Regulation of consumption, production and demand is universal. The formation of consumption units [illegible] is regulated by means [illegible] by regulations of [illegible] families, property, marriage, and ceremony, and [illegible] adjustment to physical conditions. This may effectively limit [illegible], as in Tibet and [illegible], by [illegible] and religious [illegible]. [illegible] is found in Near East [illegible] urbanization [illegible] among the [illegible] and [illegible] by [illegible] for younger [illegible]. [illegible] with strong [illegible], which [illegible] developmental [illegible] economic [illegible], such as the [illegible] World War II, [illegible] fertility, even survival is selectively regulated [illegible] the abandonment of the aged [illegible] population among such peoples as the Chukchi and the Eskimo. Infanticide and abortion are old, [illegible] and effective means of regulating population size [illegible]. [illegible] Europe, [illegible] Japan, [illegible] in Japan and Hungary, half or more of all conceptions are aborted. Present [illegible] property [illegible], [illegible] and social mobility [illegible]. Finally, other types of demands [illegible] also [illegible]. This plasticity of demand, [illegible], represents [illegible] adaptive [illegible].

3. [illegible] The [illegible] tools [illegible] such [illegible] and [illegible] Organisms [illegible] cattle [illegible] tools [illegible] and [illegible] of [illegible] concept of property, of [illegible] use of tools and [illegible].

4. The [illegible] of [illegible] and materials.

[illegible] useful and [illegible]

and appropriate devices are essential. These generate natural cycles and distributions of human activity, enhanced in effectiveness by division of labor and exchanges. The perception of utility in by-products has greatly extended the range of useful foodstuffs and materials. For example, both acorn meal in aboriginal California and bitter manioc in the Amazon were undoubtedly by-products of poison extraction, wherein the primary product was used for stunning fish and killing fleeting game and the food came as a starvation expedient. Metallurgy (from easily reducible oxides) probably arose from using fire for cooking, baking pottery or flint extraction. Finally, the reduction of external competition, e.g. by burning off unwanted timber, and of internal competition, e.g. in herds, by castration of extra males aid harvesting. Upgrading through deliberate selection and breeding is new.

d. The capture of external energy. Fire, gravity, domestic animals, wind, gas expansion and radiation comprise the forces successfully tapped by man for productive use. Vast increases in the scale of external energy use have taken place in industrial countries; in the United States in 1955, inanimate energy use per capita came to 61 million kilocalories (Schurr-Netschert, p. 264), compared to a maximum of 2,500,000 kilocalories ingested as food both directly and also via animals, making allowances for loss in conversion between fodder and animal products. Increases in the thermal and economic efficiency of energy use, in the ready transmittal of energy, and in the range of its applications have also been fundamentally important.

e. The transformation of materials and energy. Man has, through heat, fermentation, and other physico-chemical reactions been able to up-grade foodstuffs and materials to usable form, and to recover otherwise wasted materials and energy. Grinding, more rarely chemical treatment such as reduction (hominy), and cooking transformed grains into food; brewing did as well, but also led to vitamin-B synthesis and to exhiliration. Fermentation by well-tolerated bacteria to generate environments too acid for highly toxic strains helps preserve grain, dairy products and fish; drying, salting, freezing represent other resource extenders. Materials recovery, e.g. scrap reprocessing, immensely conserves energy and resources; in the United States today, about half of all metal worked and a third of the paper is from scrap.

f. Storage and feedback of reserves. Stored materials, accumulated tools and instruments (or fixed capital), and recorded or memorized information comprise man's means of insuring continued consumption and survival with intermittent effort. These reserves allow experimentation without stress, and the discrimination of maximum returns.

2. Man's ecological capacities. In general, five capacities have developed in consequence of man's strategy of environmental use:

a. His mobility, perceptive abilities, computational skill, memory, strength and manipulative dexterity have been artificially multiplied

and appropriate devices are essential. These generate natural cycles and distribution of human activity, enhanced in early times by division of labor and exchanges. The discovery of utility in by-products has greatly extended the range of useful plants and materials. For example, both acorn meal in aboriginal California and bitter manioc in the Amazon were undoubtedly by-products of poison extraction, whereas the primary product was used for stunning fish and killing fleeing game and the food came as a serendipitous expedient. Metallurgy from easily reducible oxides probably arose from using fire for cooking, heating pottery or fuel extraction. Finally, the reduction of external competition, e.g., by hunting off unwanted animals, and of internal competition, e.g., by weeding, by castration of extra males and harvesting. Upgrading through deliberate selection and breeding is new.

d. The capture of external energy. Fire, gravity, domestic animals, wind, gas combustion and nutrition, horses, the forces successfully tapped by man for accelerative use. Vast increases in the use of external energy have taken place in industrial societies. In the United States in 1968, per capita energy use per day came to 61 million kilocalories. To put [illegible] compared to a consumption of 2,500, and directly ingested as food both directly and also via cereals, making allowances for losses in conversion of vegetable and animal products. Increases in the thermal and economic efficiency of energy use, in the ready transmission of energy, and in the range of its applications have also been fundamentally important.

e. The transformation of materials and energy. Mankind, through heat, fermentation, and other physico-chemical reactions been able to upgrade foodstuffs and materials to usable form, and to recover otherwise wasted materials and energy. Cooking, more rarely chemical treatment such as reduction [illegible] and cooking, of sprouted grains into food, brewing, distilling, [illegible] fermentation, [illegible] with selected bacteria to generate environments too acid for highly [illegible] organisms preserve fruits, dairy products and fish; drying, salting, freezing [illegible] further preserve resources. Materials recovery, e.g., through recycling, conserves energy and resources; in the United States today, about half of all metal produced and a third of the paper is from scrap.

f. Storage and technical reserves. Stored materials, [illegible], and [illegible] made possible continued consumption and survival with unremitting effort. These reserves allow experimentation without stress, and the [illegible] of maximum [illegible].

g. Man's ecological capacities. In general, the capacities have developed [illegible] of his increasing [illegible] and use.

h. His mobility, perceptive abilities, computational skill, memory, strength and manipulative [illegible] have been greatly multiplied

b. He has replicated his digestive system of energy and materials captured by numerous, extensive and varied external, artificial circulations.

c. He has created artificial macro-habitats as well as micro-habitats; with his symbiotes and parasites he has partially achieved an artificial biome.

d. Through these means, he has developed a capacity to occupy, not merely a niche, but an eco-space, with considerable exchanges possible between desired trophic level and population density.

e. Finally, through storage, he has provided the means for alternatives over time. Thus, man has gained the possibility for a range of behavioral activity and inactivity far beyond all other species.

3. Ecological commitments and the limits of pragmatism. In general, the meeting of primary needs, especially the food quest, have occupied the bulk of human activity until the Industrial Revolution. At a maximum, with the aid of imposed controls, and with periodic hazards of famine, even the leading cultures of the eighteenth century could free a fifth of their populations for urban life, and a very few for cultivated leisure and pomp. Yet even the poorest people have significant forms of expression--Upper Paleolithic and African Bushman painting, Australian and Shoshone oral literature, Eskimo sculpture. And even dilettantes and wastrels may precipitate discovery: statistics arose from the gambling table. Religious movements may spring out of periods of intense moral concern, as in the Roman Empire (Bell), but once established may act as ecological regulators of major importance. The religious origins of modern hospitals and universities are cases in point. Thus ecological pragmatism, although a powerful guide to human culture, is a limited one.

Required Reading

C. Daryll Forde: "Foraging, hunting and fishing," in Singer I: 154-186.

Other References

H. Idris Bell: Cults and Creeds in Graeco-Roman Egypt. New York: Philosophical Library, 1953. pp. 105.

H. E. Driver and W. E. Massey: Comparative Studies of North American Indians. (Trans. Amer. Philos. Soc. vol. 47, pt. 2) Phila., 1957, esp. pp. 363-407.

S. H. Schurr and B. C. Netschert: Energy in the American Economy, 1850-1975. Johns Hopkins Press, Baltimore, 1960. esp. pp. 31-190.

b. He has accelerated his rate of consumption of energy and materials by numerous, extensive and mixed exchanges, external circulation.

c. He has created artificial micro-habitats as well as macro-habitats with his synthetics and substitutes to meet distinctly artificial needs.

d. Through these means, he has increased his capacity, not merely physical, but also in quality, with consequent [illegible] between desires or gross level and population density.

e. Finally, through strategic [illegible] he has extended the means for alternatives over them. Birth, [illegible] and gained the capacity for a range of behavioral activity and creativity far beyond all other species.

3. Ecological considerations and the growth of population. In general, the need for primary goods, especially for food and fiber, occupied the bulk of human activity until the Industrial Revolution. At [illegible] with the aid of improved methods, and with periodic bursts of famine, even the leading cultures of the eighteenth century could spare a fifth of their populations for [illegible] [illegible] Even the [illegible] importance. The religious origins of modern hospitals and universities are cases in point. Thus ecological [illegible] [illegible] [illegible] to human culture, is a [illegible].

Required Reading

C. Daryll Forde, "Foraging, hunting and fishing," in Singer I: 154-186.

Other References

[illegible] [illegible] [illegible] New York: Philosophical Library, 1952, pp. 105.

H. [illegible] and W. E. [illegible] Community Studies of North American [illegible], Trans. Amer. Philos. Soc. vol. 17, pt. 3 [illegible], 1951, pp. 323-427

J. H. [illegible] and D. [illegible] [illegible] in the American Economy 1850-1950, [illegible] Baltimore 1960, pp. [illegible]-190.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369,
Physiology 369, Sociology 369, Veterinary Science 369, and
Zoology 369)

Lecture 22. Processes of Socio-cultural Evolution (Shimkin)

During the nineteenth century, students of culture accepted without significant exception, the idea of human cultural unity. The phenomenon was believed to arise from inherent similarities of the human mind. Cultural differences were ascribed to varying levels of achievement on a single evolutionary scale, the apex of which was represented by the totality of contemporary Western civilization.

Within this frame of reference, theories of considerable sophistication emerged. In particular, Herbert Spencer's Principles of Sociology formulated basic concepts of cultural growth:

"Recognizing the primary truth that social phenomena depend in part on the natures of the individuals and in part on the forces the individuals are subject to, we see that these two fundamentally-distinct sets of factors, with which social changes commence, give origin to other sets as social changes advance. The pre-established environing influences, inorganic and organic, which are at first almost unalterable, become more and more altered by the actions of the evolving society. Simple growth of population brings into play fresh causes of transformation that are increasingly important. The influences which the society exerts on the natures of its units, and those which the units exert on the nature of the society, incessantly co-operate in creating new elements. As societies progress in size and structure, they work on one another, now by their war-struggles and now by their industrial intercourse, profound metamorphoses. And the ever-accumulating, ever-complicating super-organic products, material and mental, constitute a further set of factors which become more and more influential causes of changes. So that, involved as the factors are at the beginning, each step in advance increases the involution, by adding factors which themselves grow more complex while they grow more powerful." (Principles of Sociology, I: 14).

Spencer anticipated many later findings. For example, his social typology approached Julian Steward's levels of socio-cultural integration. Spencer differentiated simple, compound, doubly compound, and trebly compound societies (the last being unstable empires). These levels were differentiated by the increasing formation of classes (arising ultimately out of primitive captive slavery), and of occupational groups. Within each level, there were different intensities of integration (from headless, to stable

[illegible] ANTHROPOLOGY

(Listed also as [illegible] Geography 205, [illegible] 465, Planning [illegible], Sociology [illegible], Veterinary Science [illegible], and Zoology [illegible])

Lecture 5.1. Precursors of Socio-cultural Evolution (Spencer)

During the nineteenth century, students of culture accepted without [illegible] the [illegible]. The phenomenon [illegible] to classify the different manifestations of the human world. Cultural differences were ascribed to varying levels of achievement on a single evolutionary scale, the apex of which was represented by the society of contemporary Western civilization.

Within this frame of reference, theories of considerable sophistication emerged. In particular, Herbert Spencer's Principles of Sociology [illegible] concepts of cultural growth:

"Recognizing the primary truth that social phenomena depend in part on the nature of the individuals and in part on the forces to which they are subject, we see that these two fundamentally distinct sets of factors, with which social changes commence, give origin to other sets of factors as [illegible] changes. The [illegible] and [illegible], which are at first [illegible] by the actions of the evolving society. Simple growth of population brings into play fresh causes of transformation that are increasingly important. The influences which the society exerts on the natures of its units, and those which the units exert on the nature of the society, incessantly co-operate in creating new elements. As societies progress in size and structure, they work on one another, now by their war-struggles and now by their industrial intercourse, [illegible] metamorphoses. And then the ever-accumulating, ever-complicating super-organic products, material and mental, constitute a further set of factors which become more and more influential causes of change. So that, [illegible] as the factors are at the beginning, each step in advance increases [illegible], by adding factors which themselves grow more complex while they grow more powerful." (Principles of Sociology, I: [illegible]).

Spencer anticipated many later findings. For example, his social typology approached Julian Steward's levels of socio-cultural integration. Spencer differentiated simple, compound, doubly compound, and trebly compound societies (the first being unstable [illegible]). These levels were differentiated by the increasing [illegible] of classes (arising ultimately out of primitive captive slavery), and of occupational groups. Within each level, there were different intensities of integration (from headless, to stable

headship) and ecological variants (nomadic, semisettled, settled). Finally, all societies could be grouped into one of two configurations, militant or industrial. Each level, integrative pattern, ecological variant and configuration generates appropriate social correlates. (Ibid., esp. I: 537-563). Illustrative of these correlates is the following: "Generally when the militant type is highly developed, the political head and the ecclesiastical head are identical--the king, chief descendant of his ancestor who has become a god, is also chief propitiator of him (Ibid., I: 548)." Over seventy years later, Robert Lowie, utilizing extensive data for native America, rediscovered this theory.

After World War I, critical field work and theoretical studies, especially by Franz Boas, Bronislaw Malinowski and their students yielded findings discrediting early evolutionism. Four areas of weakness were established:

1. The specific correlations between cultural stages and traits postulated especially by Morgan and Marx did not correspond to the facts. Neither primitive communism nor primitive promiscuity could be substantiated; bilateral or patrilineal rather than matrilineal groups characterized the simplest cultures. Subsistence systems and socio-political institutions had no regular correspondences: Plains Indian hunters had strict police systems with true legal authorities, institutionalized warfare, social grading, etc. Conversely, Philippine cultivators dependent upon great systems of irrigated terraces lacked central authority and cities, yet had elaborate, effective laws based on kinship obligations, arbitration by go-betweens and stylized feuding.

2. Man's environmental adaptations were both incomplete and often secondary. Oriental cultivators used cattle solely as draft animals, eschewing dairy products. African herdsmen used dairy products and cattle blood, but failed to use animals for power. Moreover, Eskimo technology was found via archeology to be, not a response to Arctic harshness, but a reduction of cultural elaboration reached far earlier in the richer area of the Bering Sea.

3. Correlated with the disproof of naive environmentalism was increasing evidence of widespread cultural diffusion. Borrowing emerged as a major alternative to internal evolution.

4. Above all, the bankruptcy of Victorian values in World War I and the discovery of substantial intellectual achievements, and of consistent rationales, even among humble peoples such as the Trobriand Islanders (Malinowski), the Winnebago (Radin) and others, led to a rejection of a single evolutionary scale. Were West African rhythms or the subtleties of artistic distortion in West African sculptures really inferior to the thump-thump of Victorian hymns or the gingerbread of Victorian architecture? Did laissez faire provide ethical standards more advanced than those of the Crow?

An additional generation of research has been needed to reexamine the empirical evidence of cultural variation and development. Since World War II, a neo-evolutionism more fully reconciling theory and evidence has arisen in the United States, led especially by Julian Steward. The essence of this viewpoint, also termed multilinear evolution, is as follows:

1. Socio-cultural evolution can be accepted as a synthetic observation of world-wide, historic trends toward objectively more effective technologies, population growth, more extensive social and spatial ordering, and behavioral diversification. Various stages of capacity by these criteria can, furthermore, be defined as <u>levels of socio-cultural integration.</u> These include kinship-based, subsistence-dominated societies; stratified and nucleated aggregations, integrated, theocratic monarchies; etc. This taxonomy is a basic device for structural analysis, but it involves no assumptions of common historical origins, nor any moral evaluation. It explicitly excludes phenomena of a biocultural and expressive nature which are largely independent of economic capacity.

2. While physical factors such as food supply, means of transportation, and the like <u>limit</u> attainable levels of integration, stimulus-response hypotheses are inadequate to explain cultural developments. Societies usually have several alternatives to stress situations, <u>e.g.</u> population control, and historically observed conditions of extreme stress induce messianic movements and other escapist reactions (Plains Indian Ghost Dance, etc.) rather than adaptation. An alternative hypothesis of cultural development is as follows:

a. Cultural innovations are constantly developing as results of transmittal errors, intellectual play with exciting patterns, contextual changes and deliberate disjunctions. Their acceptance depends upon a social perception of distinctiveness, physical or psychological utility, and compatibility with existing practices.

b. Societies aggregate behavior into patterns characterized by codes of relationship which conform to physical requirements (<u>e.g.</u> technology) and to group standards of symmetry, comprehensiveness and closure. Patterns yield approved combinations of action, within which behavior is institutionalized and facilitated (vision quests or scientific research), and beyond which even useful adaptations tend strongly to be inhibited.

3. Internal innovation and diffusion (or borrowing) are not alternative but complementary forces of change. Diffusion is maximized by parallel evolution which permits the ready integration of new elements into existing patterns, <u>e.g.</u> crops between agricultural people. It induces widespread effects from changes in economic opportunity and other social alternatives, <u>e.g.</u> the lessening of kinship ties as a consequence of desires

An additional generation of research has been needed to reexamine the empirical evidence of cultural variation and development. [illegible], a neo-evolutionist, more fully reconciling theory and evidence, [illegible] in the United States, and especially by Julian Steward. The essence of this viewpoint, also termed multilinear evolution, is as follows:

1. Socio-cultural evolution can be conceived of as [illegible] of [illegible]. Long-run trends toward objectively more effective technologies, population growth, more extensive social and spatial ordering, and behavioral diversification. Various stages of [illegible] can, furthermore, be defined as levels of socio-cultural integration. These include [illegible], subsistence-[illegible], [illegible] and [illegible], integrated, [illegible]. This taxonomy is a basic device for structural analysis, but it involves no assumptions of [illegible] historical origin, nor any [illegible] evolution. [illegible] whose progressive nature are largely independent of [illegible] capacity.

2. [illegible] factors such as food supply, [illegible], and [illegible] are [illegible] to explain cultural development. [illegible] to [illegible], e.g., population control, and historically observed [illegible] and other examples [illegible]. [illegible] of cultural development is as follows:

3. Cultural innovations are constantly developing as a result of experimental efforts, [illegible] with existing patterns, [illegible]. Their acceptance depends [illegible] perception of [illegible], physical or psychological [illegible], and [illegible] principles.

4. [illegible] behavior into patterns [illegible] by [illegible] physical requirements (e.g., [illegible]) and [illegible] standards of symmetry, comprehensiveness and [illegible]. [illegible] of action, within which [illegible], and [illegible] to be [illegible].

5. [illegible] diffusion (or borrowing) are not alternative [illegible] of change. [illegible] integration of new [illegible] into existing patterns, e.g., [illegible]. [illegible] opportunity and [illegible], e.g., [illegible] as a consequence [illegible].

for individual betterment. Finally, it produces conflicts which lead to replacement, rejection or accommodation between old and new. In culture, functionally equivalent traits follow the law of competitive exclusion. Co-existence is possible only when psychologically distinctive attributes are given each, e.g. traditional clothing for holidays.

4. The observed facts of culture history, comparative ethnography (including those of modern cultures), and of ongoing change are consistent with generalizations based on broad equivalences of structure and function (kinship-based societies as opposed to "matrilineal clans").

Required Reading

J. H. Steward and D. B. Shimkin: "Some Mechanisms of Sociocultural Evolution," Daedalus Summer 1961, pp. 477-497.

Other References

H. G. Barnett: Innovation: The Basis of Cultural Change, New York: McGraw-Hill, 1953.

M. S. Briggs: "Town-planning from the ancient world to the Renaissance," in Singer III, pp. 269-299.

A. R. Hall: "The rise of the west," in Singer III, pp. 709-722.

H. S. Harrison: "Discovery, invention and diffusion," in Singer I, pp. 58-84.

C. Singer: "East and West in retrospect," in Singer II, pp. 753-776.

Lecture 23. Stages of Socio-cultural Evolution (Shimkin)

The identification of approximate landmarks of social development or levels of socio-cultural integration, in J. H. Steward's terminology, retains considerable analytic value even when stripped of imputations of historical "law" or inevitable sequence. These landmarks can serve as devices for the functional study of similar cultures in different contexts of time and place. Conversely, the diversity of types ascribable to larger geographical areas at particular times leads to questions about the nature and mechanics of their interrelationships. Both approaches aid in isolating basic cultural adaptations from more mobile patterns and elements, which might be regarded as stylistic overtones.

Three general approaches have been tried in cultural typology.

1. The first, characteristic of Toynbee's (1947) and Kroeber's (1944) investigations,* centers on regional traditions or civilizations, such as those of China, India and Western Europe, and seeks to define the stages of growth and decline for each. In Toynbee's work, these reconstructions have been exemplifications of a general theory of cultural growth, from a period of initial ecological challenge (physical or social), a "time of troubles" during which effective responses are found, dissemination to a "universal state", to a final decadence and supersession. Kroeber is more circumspect, and gives no necessary sequence to the pulsations of creative activity which his data indicate to have been intermittent phenomena in every major culture. Both men emphasize non-material culture: Toynbee, religion; and Kroeber, the arts.

2. The technique of identifying stages by index features, such as agriculture and writing, characterizes the writing of the nineteenth century evolutionists, including Spencer and E. B. Tylor. This system is more objective, but faces the dual hazards of excessive grossness, if only one index item is used, or of uncertainty when multiple criteria are utilized and fail to coincide. Should the intellectual achievements of the Maya, writing and a positional number system, outweigh the administrative triumphs of the Incas? Is it most important that the Hittites and the Incas had remarkable similarities in the nature of their kingship, supporting social stratification, socio-religious mechanisms, religious organization and ceremonialism, law and administration? Or should the differences in agricultural practice--hoe

*Both of which are derivative from Oswald Spengler.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology [illegible], Geography [illegible], Health Education [illegible]
Physiology [illegible], Sociology [illegible], Zoology [illegible]
January [illegible]

Lecture 23. Stages of Socio-cultural Evolution (Theories)

The identification of successive "stages" of societal development or levels of socio-cultural integration, in J. H. Steward's terminology, retains considerable analytic value even when stripped of implications of historical "law" or inevitable sequence. These formulations are actually a device for the functional study of similar cultures in different contexts of time and place. Conversely, the diversity of types ascribable to different geographical areas at particular times tends to [illegible] about the [illegible] and mechanics of their interrelationships. Both approaches aid in isolating basic cultural adaptations from more mobile patterns and elements, some of which might be regarded as stylistic overtones.

Three general approaches have been tried in cultural typology.

1. The first, in the tradition of Toynbee's (1934) and Spengler's (1926)* investigations, centers on regional traditions or civilizations, such as those of China, India and western Europe, and seeks to define the stages of growth and decline for each. In the cyclic works these reconstructions have been exemplifications of a general theory of cultural growth, from a period of initial ecological challenge (physical or social), a "time of troubles" during which effective responses are found, [illegible] to a "universal state", to a final decadence and disintegration. The theory is more culturally limited and gives no necessary [illegible] to the pulsation of [illegible] activity which [illegible] data indicate to have been the dominant phenomenon in every complex culture. Both men emphasize the non-material culture: Toynbee, religion; and Spengler, the arts.

2. The technique of identifying stages by index features, such as agriculture and writing, characterizes the writing of the nineteenth century evolutionists, including Spencer and E. B. Tylor. This approach is more objective, but faces the dual hazards of excessive generality if only one index item is used, or of uncertainty when multiple criteria are utilized and fail to coincide. Should the intellectual achievements of the Maya, writing and a positional number system, outweigh the administrative triumphs of the Incas? Is it more important that the Hittites and the Incas had remarkable similarities in the nature of their kingship, supporting social stratification, socio-religious mechanisms, religious organization and [illegible], law and administration? Or should the difference in [illegible] of practice [illegible]

*Both of which are derivative from Hegel and Spengler.

versus plow, irrigation versus dry farming, potatoes rather than grapes--be given primacy? Finally, the problems of rejuvenated and recurrent institutions are difficult. Can clan systems expanded through elaborate rationalizations of relative seniority and fictional genealogies to meet the military and administrative needs of nomadic states, as among the Turks, still be identified as kindred? Are the theocratic pretensions, the class stratifications, the bureaucracies, the police systems, the economic controls of Western European Enlightened Autocrats sufficient to group these societies with the Asiatic and Mediterranean Empires from Cyrus' Persia onward?

The ultimate tests of groupings such as these are their capacities to provide plausible and fairly uniform explanations of variance, and especially to disclose unsuspected similarities in cultural characteristics and dynamics. At present, a seven-fold, socio-political classification appears to be broadly valid and analytically fruitful.

a. Kinship-based, subsistence-dominated societies. Such structures were universal until the invention of fishing techniques in the Mesolithic, and were still extant within the past century among marginal peoples (South African Bushmen, African and S. E. Asian Negritos, Tasmanians, Central Eskimo, Basin Shoshoneans; Siriono, Ona and Alacaluf in South America, etc.). The fundamental features in these groups are limits in food resources and mobility restricting permanent groups to 50 persons or fewer, hence to traceable kin. Collective hunts and other times of fleet food surplus permit the assembly of simple communities of, say, 150 persons. These are prime occasions for courtship and ceremonialism. Shamans are usually the sole specialists, but distinct behavior patterns between particular sets of relatives and individual, incorporeal property are common. (Steward, 1955, pp. 101-142).

b. Expanded primary societies are associated with improvements in food supply (large-scale fishing, intensive gathering and small-scale agriculture) or in mobility (water transport, reindeer, horses) permitting permanent groups of several hundred and temporary assemblies of a thousand persons or more to arise. Limited, often unstable, status differentiation and elementary political authorities (chiefs, shamans or priests, police), devices of self-identification (group names, cemeteries, war cries) and rituals are common. Warfare over economic resources is characteristic. In general, expanded primary societies include semi-sedentary peoples (Mohave, Yokuts, Pomo, Hupa in California; Pueblo Indians; Ge of Eastern Brazil) with important plant resources, and mobile hunters (Ostyak, Tungus, Chukchi of Siberia; North American Plains Indians; Guarani of South America). The former probably represent a general state emerging in favored localities during the Mesolithic and early Neolithic; the latter are late acculturations to contacts with richer cultures or impoverishments in hostile environments. (Steward, 1955, pp. 143-172).

versus plow, irrigation versus dry farming, potatoes versus grain grasses--be given primacy? Equally, the problems of separate and recurrent institutions are difficult. Can kin systems expanded through clubs note intensifications of relative status, and broader genealogies to meet the military and administrative needs of complex states such as the Tonga, still be dealt with as kin-based? Are the theocratic pretensions, the class stratifications, the bureaucracies, the political systems, the economic controls of Western European (enlightened) states sufficient to group those societies with the Aztecs and the dynasties of Pharaohs from Cyrus' Persia onward?

The ultimate test of groupings such as these are their capacities to provide plausible and fairly uniform explanations of variation, and especially to disclose unsuspected similarities in cultural characteristics and dynamics. At present, a general kind, socio-political classification appears to be broadly valid and moderately fruitful.

a. Kinship-based, single-community integrations. Such structures were universal until the invention of farming techniques in the Mesolithic, and were still extant within the past century among marginal peoples (South African Bushmen, Western and S. E. Asian Negritos, Tasmanians, Central Brazilian Ge, Basin Shoshoneans; Siriono, Ona and Yahgan in South America, etc.). The fundamental fact about these groups was limits in food resources and constant shifting, permitting permanent groups of 50 persons or fewer, hence to kin-based ties. Cooperative hunts and other times of food surplus permit the assembly of ample communities of, say, 100 persons. There are few such occasions for community-wide integration. Status, or usually the sole specialization, is limited to patterns between sets of relatives and individuals. Decentralized groups are common. (Steward, 1955, pp. 101-150).

b. Expanded primary settlements are associated with improvements in food supply (lower-river fishing, intensive gathering and small-scale agriculture) or in mobility (water transport, reindeer, horses) permitting permanent groups of several hundred and temporary assemblies of a thousand persons or more at times. Kin-based, often unstable status differentiation and rudimentary political authority (chiefs, shamans, priestly graded), degrees of role-definition (gerontocracies, confederacies, war chiefs and rituals) are common. Warfare over economic resources (the peace...) in general, expanded primary groupings include semi-sedentary groups (Mohave, Yokuts, Pomo, Hupa in California; Pueblo Indians; Ge of Eastern Brazil) with improved plant resources, and mounted hunters (Apache, Tupi, Chukchi of Siberia; North American Plains Indians; Charrua of South America). The former probably represent a general state emerging in favored localities during the Mesolithic and early Neolithic; the latter are late specializations due to contacts with richer cultures or improvements in hunting techniques. (Steward, 1955, pp. 150-172).

c. Ceremonially centered, multi-community, differentiated societies seemingly reflect population growth, economic diversification, including local specialization (agriculture, animal husbandry, mining, whaling, etc.), effective local communications, and regional solidarities based upon common religious values. A priesthood, often hereditary, tends the ceremonial centers, and assumes instructional, welfare and juridical roles. Regional support permits wealth accumulation at these centers; periodic markets and commercial handicrafts are also frequent correlates. Such societies have been represented in pre-dynastic Egypt, florescent Mesopotamia, coastal Peru (Chavin), Cahokia in the Mississippi Valley; the historic Natchez of the southeastern United States; the Lobi of West Africa, the Nagoo of Assam and elsewhere. (Adams, Collier, Palerm, 1955).

d. Stratified conquest states have been widespread in time and space: Shang China, Assyria, the Scythic kingdoms, the Aztec confederacy, the Iroquois Confederacy, and many Polynesian and African kingdoms are illustrative. This type of society seemingly arises from ceremonially centered groupings under the impact of two forces: an increasing concentration of wealth and power which becomes ever more demanding or intensified competition between groups from population growth, rising mobility (the Eurasian steppe), etc. Militarism allied with religion justifies absolutism, looting, human sacrifice, slavery and concubinage. Sharp differences in behavioral codes arise for rulers and ruled; among the former, warrior classes with internal mobility, courts and attendants, ideas of dignity and honor, are frequent. New requirements in material culture--arms, fortifications, transportation, roads--promote planning, directed labor, and mass production. At the same time, tyranny yields constant unrest. (Creel, 1937).

e. Integrated, bureaucratic monarchies. In the Near East after 2,000 B.C., among the Incas, and especially in Achemenid Persia, Han China and the Mourya Empire of India, the unstable conquest states grew into highly regulated, centralized empires. Bodies of officials replaced the bulk of personal rule, procedures and records ramified, civil as well as military public works became prominent, taxation replaced looting, open cities and widened commerce (often aided by currency and standard measures) generated wealth, while conspicuous consumption was much in evidence. National religious and official languages, as well as hierarchical levels of local organization, were imposed upon heterogeneous populations, which were often moved and mixed to reduce possibilities of revolt. Many of these features have recurred in subsequent eras, up to contemporary totalitarianism. (Gurney, 1954).

f. Law-based, corporate states. In the Old World, but not in aboriginal America, the major bureaucratic monarchies developed into less centralized and less authoritarian systems inadequately designated as "feudal."

The essence of these changes was an increasing emphasis upon personal choice and responsibility, exemplified by the concepts of conditional land tenure (fiefs); of personal obligations for prayer, alms, ritual abstinences, and other-worldly salvation; and of potential release from worldly pressures through monasticism. Human sacrifice vanished and slavery, although continuing, received censure. Corporate bodies--guilds, religious organizations, nobles and peasants--became the foci of social activity, including welfare and burial. These bodies were largely self-regulating, and public law attended mostly to inter-group conflicts. These changes appear to have been associated with greater requirements of capital and skill in urban activities (metallurgy, masonry, etc.), which promoted military autonomy at low cost, and with agricultural stagnation. Societies of this type arose in the Mediterranean in late Hellenistic times, and characterize much of the Middle East and India even now. (Coon, 1951).

g. Mobile, persuasion-controlled, high-energy societies are developing world-wide today. High agricultural productivity, unparalleled urbanization, mass communications, general education and individualized status have been superimposed upon law-based corporate systems to yield structures of extraordinary complexity, controllable only with the informational means of the machine age.

3. The third approach to cultural classification is in relation to the development of major cultural patterns. For example, industrialization has comprised two phases, elemental and complex. Elemental industrialization we find to be a system of maximizing the output and efficiency of fabricating activities by the introduction of five complementary practices:

(1) The breakdown of products and processes into parts and stages susceptible to separate handling.

(2) The standardization of these parts and stages so that uniform outcomes emerge from the assembly of similar units, or the conduct of similar series of procedures.

(3) A shift from self-sufficient sets of skills and procedures to specialization and systematic exchange.

(4) A change from purely custom work to satisfy needs as they arise to the anticipation of demand.

(5) A change from unit or irregular volumes of production to standardized batch or even continuous flow output.

Applying these concepts to specific cultures, we can note that virtually no hunting and gathering people have the cultural prerequisites for industrialization. At the same time, elemental industrialization is an old phenomenon, well developed by 2000 B.C. in the Near East, and characteristic of many agrarian societies.

The [illegible] of these changes [illegible]
choice [illegible]
tenure [illegible]
and [illegible]
certain [illegible]
continuing [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
activities [illegible]
of low cost. [illegible]
in the [illegible]
[illegible]

2. [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

3. [illegible]
[illegible]
[illegible]
we find [illegible]
[illegible]

(a) [illegible]
[illegible]

(b) [illegible]
[illegible]

(c) [illegible]
[illegible]

(d) [illegible]
[illegible]

(e) [illegible]
[illegible]

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

Since the eighteenth century, elemental industrialization has been transformed in Europe, the United States and Japan by a series of developments which have proceeded in two distinct lines, market economics or private capitalism and command economics or State capitalism. Both lines of evolution have been evident in every country. In the United States, for example, land grants underwriting railroad construction and protective tariffs were present along with entrepreneurship. In Russia, both before and since the Revolution, the peasant entrepreneur has continually given State or State-fostered activities intense competition in the area of consumer goods and services (Shimkin, 1952). Nevertheless, a general dichotomy seems valid.

The main developments leading from elemental to complex industrialization have included the following:

(1) New, impersonal, hierarchical and self-perpetuating organizations have developed for decision-making, the administration of resources and personnel, and the direction of production. These are the private firm and the public bureau, and the factory.

(2) Conscious, systematic and institutionalized efforts have been undertaken to expand resources and promote useful innovations. Under State capitalism, the motivations for such efforts have centered in the promotion of national power, and Academies of Science have served as typical instruments. Under private capitalism, profit opportunities and competitive pressures have provided stimuli, while the instruments have been diverse. Individual efforts protected by patents and similar guarantees; various contract arrangements; and specialized organizations have all been employed.

(3) These innovations have been particularly expressed in the harnessing of inanimate energy for motive power and in the mastery of a tremendous range of physico-chemical processes. Together, these innovations have made possible tremendous increases in the volume of output and in labor productivity, and entirely new classes of goods and services.

(4) Simultaneously, they have introduced new problems of obsolescence for skills, natural resources and equipment. In consequence, the demands of industrialization upon the surplus of an economy are intensified by the need to replace the old-fashioned as well as the worn-out, in addition to providing for growth in demand. Under State capitalism, economic compartmentation permits highly selective replacement, and the real costs of obsolescence in low-priority sectors are reflected in open or hidden subsidies and underemployment. Under private capitalism, the effects of obsolescence are ubiquitous and the costs are reflected in unused capacity and unemployment.

(5) Finally, the system of industrialization has spread from manufacturing to all other economic activities, to varying degree. A modern American poultry or grain farm is precisely as much an industrial establishment as a textile mill.

Required Reading

Steward, J. H.: Theory of Culture Change. Urbana: Univ. of Ill. Press, 1955, pp. 178-209.

Wilson, C: "Technology and Industrial Organization: in Singer V: 799-813.

Other Readings

Adams, R. M.: "Developmental Stages in Ancient Mesopotamia," pp. 6-18 of J. H. Steward (ed.), Irrigation Civilizations: A Comparative Study. (Washington: Pan American Union, 1955).

Collier, D.: "Development of Civilization on the Coast of Peru," pp. 19-27 in Irrigation Civilizations, op. cit.

Coon, C.: Caravan. The Story of the Middle East. New York: Holt, 1951 pp. 376.

Creel, H. G.: The Birth of China. New York: Reynal & Hitchcock, 1937. pp. 402.

Gurney, O. R.: The Hittites. London: Penguin Book, 1954. pp. 240.

Kroeber, A. L.: Configurations of Culture Growth. Berkeley: Univ. of California Press, 1944. pp. 882.

Palerm, A.: "The agricultural bases of urban civilization in Mesoamerica," pp. 28-42 of Irrigation Civilizations, op. cit.

Shimkin, D. B.: "Industrialization, a Challenging Problem for Cultural Anthropology," Southwestern Journal of Anthropology 8: 84-91, 1952.

Toynbee, A.: A Study of History. Abridgement of Volumes I-VI by D. C. Somervell. New York: Oxford, 1947. pp. 618.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 24. Evolution of the Food Quest. Introduction to Lectures 24-30 (Shimkin)

The development of man's capacity to procure, process, store and distribute food has been the foundation of all other cultural advances, and the source of man's most pervasive influences upon natural habitats. At the same time ecological possibilities and constraints have continually dictated the technological evolution of the food quest. The biological characteristics of the plants and animals exploited, and the climate, soils and topography of each habitat have set corresponding requirements. Thus, while domesticates and food procurement technology have been diffused between areas, and while natural conditions have often been greatly modified, each of the biomes (from tropical forest to tundra) and each of the zoological regions (from Ethiopian to Holarctic) has had a distinctive evolutionary sequence for the food quest. Even where, as in Australia and New Zealand, entire biotas have been transplanted, the relations between native and introduced species have precipitated unique problems, e.g. the rabbit nuisance in Australia and the sheep-killing habits acquired by New Zealand parrots.

Five basic types of food procurement can be recognized: hunting, fishing, gathering, agriculture and pastoralism. Hunting appears to have been a practice even of the Australopithecines, but fishing appears only in the Mesolithic era, and the wet, warming climate of the Boreal period. Fruits, nuts and greens form part of all Primate diets, but the systematic gathering of seeds, edible piths and roots necessitated technological innovations--digging sticks, winnowing baskets, seed grinding, straining, cooking, etc. These seemingly developed in the early Atlantic period in the Old and New Worlds alike, perhaps 10,000 years ago. Within two or three thousand years they were succeeded by agriculture of several types, which unquestionably developed independently in several centers.

Agricultural evolution has involved repeated parallel developments (e.g. irrigation, manuring), diffusions of successful domesticates, and the suppression of competitors. Thus, Chenopodium or goosefoot was once an important crop both in the Old and New Worlds, although it is today only a weed. Especially important stages in agricultural development include (1) the development of draft-animal plowing, sickles, irrigation and permanent field operation in the Near East by 3000 B.C.; (2) the domestication of the major Mediterranean tree crops--olive, orange, etc.--by 1000 B.C.; (3) the great crop interchanges between the West, China and India from about

INTRODUCTORY [illegible]

Anthropology [illegible]

Department of [illegible]

[illegible]

Lecture 21. Domesticating the Food Quest. Introduction to [illegible]

[illegible]

The development of [illegible] domestication of plants and animals [illegible] and other cultural [illegible] source of [illegible] The biological [illegible] Thus [illegible] while [illegible] from [illegible] Ethiopia) [illegible] Some cases, as in Australia and New Zealand, [illegible] sheep-herding [illegible]

Five basic types of food production can be recognized: [illegible] fishing, gathering, [illegible] and pastoralism. [illegible]

Agricultural [illegible] (1) the [illegible] (2) the [illegible] (3) the great [illegible]

100 B. C. to about 700 A.D.; (4) the crop and animal interchanges between the Old and New Worlds after 1492; (5) the introduction of mineral fertilization, liming and associated soil-improvement techniques about 1750; (6) agricultural mechanization, from about 1860; and (7) scientific genetic selection, including hybridization, and pest control via insecticides, since about 1900. Each stage has permitted new spurts of population growth, world wide.

Pastoralism is the youngest form of food production. The earliest herding people, in the inner Asian steppes, were sheep raisers and seed gatherers about 2,000 B.C. Herding is often combined with part-time agriculture, as among the Turkmen, or made more certain by tame hay cultivation, often with irrigation (Altai Turks). In the Arctic, reindeer pastoralism has been an extension of reindeer-mounted hunting and the use of decoy reindeer after the extermination of the wild reindeer. It dates only to the fourteenth century in most of Eurasia.

The significance of the food quest in human ecology is determined by five factors. These are (1) the abundance, nutritional quality and reliability (including possibility of storage of the food resources exploited); (2) the quantities of labor and materials needed to procure and process the food; (3) the organization of space (land use, migrations, etc.) and of time (vegetative cycle, migrations) necessitated; (4) the possibilities of maximizing output and returns by specialization and exchanges of other products (e.g., commercial fishing, fur trapping, mono-crop agriculture); and (5) the terms of trade engendered by the social setting of food production (entrepreneurship, debt-slavery, serfdom, etc.).

Illustrative applications of these principles to non-agricultural peoples are as follows:

Aboriginally, life in the deserts and uplands of the Great Basin of North America depended upon a continuous gathering of seeds, roots and pinon nuts, supplemented only occasionally by jackrabbit or antelope meat gained through collective drives (Steward, 1938, 1955). Extreme dispersal and frequent migrations throughout a well-known foraging area were essential. Except in favored localities families were the permanent social units, with larger gatherings feasible only for short periods; the material culture was restricted to the minima transportable on human backs or readily manufactured on the spot. Yet the population densities achieved ranged from 1.5 to 16 persons per 100 sq. km., compared to 0.8 to 12 persons per 100 sq.km. for the far richer Plains (Kroeber, 1939, pp. 139-140). The basic advantages offered by pursuit of the 40 million bison of the Plains, once the horse had been acquired, were the possibility of transporting far more goods, of maintaining seasonally far greater social aggregates, of very extensive migrations (hence, intercultural stimulation), and of continuous warfare.

[illegible] (1) the [illegible] and [illegible] from the [illegible] and [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] (5) agricultural [illegible] [illegible] (7) [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] would arise.

[illegible] of the [illegible] [illegible] [illegible]. The [illegible] of [illegible].

The significance of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] (1) [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] (3) the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of [illegible] [illegible] [illegible] [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], etc.

[illegible] [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

[illegible], [illegible] [illegible] [illegible] and [illegible] [illegible] the [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] of [illegible] [illegible] and [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], 1919, [illegible]. The [illegible] of [illegible] [illegible] [illegible] [illegible], and of [illegible] [illegible].

But these advantages were limited by intermittent contact with the herds, because of their wide movements and conflict between Indian tribes. Buffalo meat in abundance was available for half the year at best; in winter particularly, dispersal after smaller game--elk, deer and antelope--was essential, and survival most difficult (Shimkin, 1947).

In central Alaska, the aboriginal pattern of hunting for caribou, moose and beaver, supplemented by fishing, permitted only a very thin population (6.5 persons per 1000 sq. km.) (Kroeber, loc. cit.). Although warfare, chieftainship, and wealth stratification were moderately developed, nuclear families were the sole winter groups, and starvation was a continuous problem.

In 1947, the population of the Fort Yukon area in Alaska had a density of about 14 persons per 1000 sq. km. New luxuries in housing, clothing, and transportation (large dog teams) were evident. All this had been achieved through the commercialization of trapping, which gave far higher returns in imported food for game caught than was directly obtainable from the land. But an unstable balance had been generated by new medical and relief aid; the former reduced the 1943-49 death rate to 33 per 1000 (compared to an extraordinary birthrate of 58 per 1000), and the latter provided a sixth of the gross resources of the population. Game was being depleted at an increasingly rapid rate. Above all, unstable demand for furs, the high capitalization in equipment and perishables needed by each trapper, and the legal uncertainties of trap-line titles made the future precarious. With new resources, however, the labor inputs of trapping had been reduced to perhaps six months' efforts; summer gardening could expand the subsistence base, but alternative employment opportunities for a genuine solution were lacking (Shimkin, 1955).

Fishing is a far more productive form of food procurement than hunting. Kroeber's study shows that, except in the Southwest, the North American population distribution was largely determined by marine and river fishing possibilities. Two basic types of fishing are known: (a) shore fishing, involving traps, weirs, or nets and gathering at favorable localities, e.g., for mollusca; and (b) floating fishing. The former is associated with precise property controls and identifications of fishing rights, e.g. Northwest California and medieval Europe. In the latter, the ownership of fishing vessels is the basis of wealth and social leadership, e.g., maritime Lapps and Chukchi. In both cases, the role of men is economically predominant. Also considerable leisure permits the development of crafts, and ceremonialism in permanent residences.

The productivity of fishing underlies considerable amounts of population growth and associated traits, e.g. extensive dog-sled operation and winter mobility. A major danger in fish-based economies is the narrow

and the advantages which [illegible] by intermittent contact with the [illegible], because of their wider [illegible] and [illegible] Indians. [illegible] subsistence was [illegible] for [illegible] specialization, [illegible] game [illegible], and survival was difficult (Oswalt, 1967).

In central Alaska, the aboriginal pattern of hunting for caribou, moose and bear, supplemented by fishing, permitted only a very low population (0.2 persons per 100 sq. km.) (Stevenson, op. cit.). [illegible] warfare over [illegible], and wealth stratification were [illegible] absent, [illegible] in the winter group, and starvation was a constant problem.

By 1967, the population of the Fort Yukon area in Alaska had [illegible] of about 1000 [illegible]. The [illegible] is hunting, fishing, and [illegible] (and [illegible]) [illegible]. All [illegible] through [illegible] of [illegible], which [illegible] for higher [illegible] in [illegible] game [illegible] directly [illegible] the land. [illegible] has been [illegible] and [illegible] the former [illegible] 1955-65 [illegible] (compared to an extraordinarily [illegible] 1969), and [illegible] of the game resources [illegible]. Game [illegible] depleted [illegible] increasingly [illegible], the high [illegible] in [illegible] by [illegible], and the rapid [illegible] made the [illegible] possible. With [illegible] resources, however, the labor inputs of [illegible] and [illegible] six months [illegible]; [illegible] gardening, could [illegible] the [illegible] and alternative [illegible] opportunities [illegible] (Oswalt, 1967).

Fishing is a far more productive form of food procurement than hunting. [illegible] study shows that, except in the Southwest, [illegible] population [illegible] largely [illegible] fishing [illegible]. The basic types of fishing [illegible]: [illegible] fishing, [illegible] weirs, or nets and [illegible] e.g., for [illegible], and [illegible] fishing. The former [illegible] e.g. [illegible] California and [illegible]. In the [illegible]. In both cases, the [illegible] of [illegible].

The productivity [illegible] population growth [illegible] e.g. [illegible].

ecological basis of fish life. Fish, in general, are very sensitive to changes in temperature and salinity. Also, some species, e.g., Pacific salmon, are cyclical in their frequencies. In the "on year" there may be ten times as many as in the "off year." In the Pacific Northwest, from northern California to the Gulf of Alaska, there are five species of salmon. Frequency changes are very moderate from year to year. The hinterland provides other food resources such as roots, nuts and game so that the economy was fairly broadly based. There was a great deal of cultural florescence, e.g. Tlingit and Haida, including the famous potlatches or competitive wealth disposals. On the Asiatic side, there was only the Dog Salmon (Oncorrynchus keta), the hinterland was much poorer, and the result was a much weaker development of culture, especially in Kamchatka. There was a great deal of pressure from starvation, and neither chieftainship nor wealth displays developed.

See mammal hunting is more profitable but is highly localized. Seal rookeries are found on certain beaches only, walrus live on mollusca, and all mammals migrate extensively. It was especially necessary to have competent boating technology. With this, and the use of the vegetable poison aconite, the Aleuts and several other North Pacific groups were able even to kill whales. These mammals provided not only food, but excellent fuel, hides and other materials (Heizer, 1943).

Required Reading

Zeuner, F. E.: "Domestication of animals," Singer, I: 327-352

Or

Zeuner, F. E.: "Cultivation of plants," Singer, I: 353-375

Other References

Beaumont, O. and J. W. Y. Higgs: "Agriculture: farm implements" Singer, IV: 1-12.

Fussell: "Agriculture: techniques of farming" Singer, IV: 13-43

Heizer, R. F.: :Aconite poison whaling in Asia and America" Bureau of American Ethnology, Bulletin 133: 415-468, 1943.

Helbaek, H.: "Domestication of food plants in the Old World" Science 130: 365-372. 1959.

Kroeber, A. L.: Cultural and Natural Areas of Native North America, pp. 242 (Berkeley: Univ. of California Press, 1939).

Laufer, B.: Sino-Iranica. Field Museum of Natural History. Anthropological Series XV: 185-630, 1919.

Reed, C.A.: "Animal domestication in the prehistoric Near East" Science 130: 1629-1638, 1959.

Shimkin, D. B. : "Wind River Shoshone Ethno-Geography" University of California Anthropological Records 5: 245-284, 1947.

ecological basis of fish life. Fish, in general, are very sensitive to changes in temperature and salinity. Also, some species, e.g., Pacific salmon, are cyclical in their frequencies. In the 'on' years there may be [illegible] as many as in the 'off' years. In the Pacific northwest, from northern California to the Gulf of Alaska, there are five species of salmon. Frequency changes are very [illegible] from year to year. The hinterland provides other food resources such as roots, nuts and game, so that the economy was fairly broadly based. There was a great amount of material for secondary uses, i.e., [illegible] and titles, including the famous potlatches — to accumulate wealth and prestige. On the Atlantic side, there was only the [illegible] salmon [illegible], the hinterland was much poorer, and the result was a much weaker development of culture, especially in Labrador. There was a great deal of pressure from starvation, and neither [illegible] nor [illegible] developed.

Sea mammal hunting is more profitable than is fishing [illegible]. Sea rookeries are found on certain beaches; many mammals live on molluscs and alternately migrate extensively. It was consequently necessary to have competent boating technology. Whaling, and the use of the [illegible] poison aconite, the Aleuts and several other North Pacific groups [illegible] whales. These mammals provided not only food, but material for hides and other uses (Heizer, 1943).

Required Reading

Zeuner, F. E.: "Domestication of animals," Singer, I: 327-352.

Zeuner, F. E.: "Cultivation of plants," Singer, I: 353-375.

Other References

[illegible], G. and J. V. V. [illegible]: "Agriculture: food production" [illegible], 130: 1[illegible].

[illegible]: "Agricultural techniques — farming," Singer, IV: 13-[illegible].

Heizer, R. F.: "Aconite poison whaling in Asia and America," Bureau of American Ethnology, Bulletin 133: 415-468, 1943.
Helbaek, H.: "Domestication of food plants in the Old World," Science 130: 365-372, 1959.
Kroeber, A. L.: Cultural and Natural Areas of Native North America, pp. 22 ff. Berkeley: Univ. of California Press, 1939.
Laufer, B.: Sino-Iranica. Field Museum of Natural History, Anthropological Series XV: 185-630, 1919.
Reed, C. A.: "Animal domestication in the prehistoric Near East," Science 130: 1629-1639, 1959.
Shimkin, D. B.: "Wind River Shoshone ethnogeography," University of California Anthropological Records 5: 245-288, 1947.

________________: "The Economy of a Trapping Center: the Case of Fort Yukon, Alaska" Economic Development and Cultural Change III: 219-240, 1955.

Steward, J. H.: Basin-Plateau Aboriginal Sociopolitical Groups. Bureau of American Ethnology, Bulletin 120, pp. 346, 1938 (Esp. pp. 46-49, 230-258).

________________: Theory of Culture Change. Urbana: University of Illinois Press, 1955, (esp. pp. 101-121.

______. [illegible]

[illegible]

______. [illegible]

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369,
Physiology 369, Sociology 369, Veterinary Science 369, and
Zoology 369)

Lecture 25. Agricultural Ecology - The Climatic Factor (Booth)

Agriculture, including both crop production and animal husbandry, one of man's most significant occupations, is also the only significant one which is even now, closely adjusted to the physical environment. Although all elements of the environment are factors in the ecology of crops and domestic animals two, climate and soils, are especially significant. Of all the elements of the crop environment, climate is the least susceptible to change by man. A major exception to this observation is man's ability to supply deficiencies of precipitation.

Climate is a composite or generalization of weather conditions and is usually expressed in terms of means. However, no real picture of climate can be obtained without some consideration of extremes. This is particularly true when dealing with climate as a factor of crop ecology since it is often the extreme conditions rather than the average conditions which are the controlling or limiting factors. Two critical figures of special significance in defining limits are a temperature of 32^{o} F. and an annual moisture situation in which precipitation is 60 per cent of evaporation. On the basis of these two criteria certain broad climatic regions may be defined. These climatic regions are useful for ecological purposes since they correspond generally with major biotic, soils, and to some degree, landform regions.

World temperatures in all their ramifications are closely related to solar energy intake. Since it receives on the average the most direct rays of the sun the greatest energy receipts are at the equator. Receipts decrease poleward with the annual total at the poles some 40 per cent of the equator receipts. However, annual variations in the length of day as well as the angle of the sun's rays result in seasonal variations in solar receipts so that, for example, at 40^{o} latitude solar receipts at the summer solstice exceed the daily receipts at the equator at the equinox, the time of maximum reception for that latitude.

A seven temperature zone pattern is common to many systems of climatic classification. There are: a tropical zone bounded by the mean monthly temperature of the coldest months of 64^{o} F. (which practically insures that no temperatures of 32^{o} or less occur), a subtropical or mild winter zone bounded on its poleward margins by a mean monthly temperature of 32^{o} for the coldest month, a middle latitude or cold winter zone bounded on its poleward margins by a mean monthly temperature of 32^{o} for the warmest

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 309, Geography 309, Health Education 309,
Physiology 309, Sociology 309, Veterinary Science 309, and
Zoology 309)

Lecture 25. Agricultural Ecology - The Climatic Factor (Cont.)

Agriculture, including both crop production and animal husbandry, one of man's most significant occupations, is also the only significant one which is even now closely adjusted to the physical environment. Although all elements of the environment are factors in the ecology of crops and domestic animals, climate and soils are especially significant. Of all the elements of the crop environment, climate is the least susceptible to change by man. A major exception to this observation is man's ability to supply deficiencies of precipitation.

Climate is a composite or generalization of weather conditions and is usually expressed in terms of means. However, no true picture of climate can be obtained without some consideration of extremes. This is particularly true when dealing with climate as a factor in crop ecology, since it is often the extreme conditions rather than the average conditions which are the controlling or limiting factors. Two critical figures of special significance in defining limits are a temperature of 32° F. and an annual moisture ratio of precipitation to 50 per cent of evaporation. On the basis of these two criteria certain broad climatic regions may be defined. These climatic regions are useful for ecological purposes since they correspond generally with major biomes, soils, and to some degree, cultural regions.

Mean temperatures and their variations are closely related to solar energy input. Since it receives on the average the most direct rays of the sun the greatest energy receipt is around the equator. Receipts decrease poleward with the annual total at the poles about 40 per cent of the equatorial amount. However, annual variations in the length of day, as well as the angle of the sun's rays result in seasonal variations in solar receipts so that, for example, at 40° latitude solar receipts at the summer solstice exceed the daily amount at the equator at the equinox, the time of maximum reception for that latitude.

A seasonal temperature pattern is common among systems of climatic classification. The tropics, for example, are bounded by the mean monthly temperature of the coldest month of 64° F. (which presumably assumes that no temperatures of 32° or lower occur), a subtropical or mild winter zone bounded on its poleward margin by a mean monthly temperature of 32° for the coldest month, a middle latitude or cool summer zone bounded on its poleward margin by a mean monthly temperature of 50° for the warmest

month. A possible substitute for this last boundary is the mean monthly temperature of 50° for the warmest month, an isotherm which corresponds to the poleward limit of tree growth (the timber line).

The moisture factor is somewhat less significant than the temperature factor in crop ecology than in biotic ecology or soil formation since man has made major adjustments in his culture to precipitation deficits. Several systems of precipitation effectiveness have been proposed. In nearly all cases boundaries have been established by comparing rates of precipitation with rates of evaporation. Complications are added to describing a moisture system by unequal seasonal distribution of precipitation and by the lack of reliability or dependability of precipitation in many areas. Theoretically there should be seven moisture zones on this planet based upon a consideration of zones of diverging and converging air circulation. These would be increased to thirteen if seasonal shifts are considered. Land and water contrasts, mountain barriers, ocean currents, and other considerations so seriously disrupt this basic system that for most practical purposes the zonal idea must be abandoned. For each of the temperature zones four moisture divisions may be recognized, a constantly wet, a wet-and-dry with over all effective precipitation, a wet-and-dry with over all non-effective precipitation and a dry. Sixteen theoretical types of climate emerge from this combination of critical temperature and moisture boundaries. Basic biotic ecological and soil boundaries correspond to those of these climatic regions. Agricultural ecological boundaries show somewhat less correspondence.

Certain critical crop and agricultural system boundaries for the United States are examined.

The optimum and limiting conditions for basic cereals, rice, corn, and wheat are examined.

Required Reading

Klages, Ecological Crop Geography, pp. 1-9, 73-82, 294-321.

Other References

Wilsie, Crop Adaptation and Distribution.

Finch, Trewartha, et. al., Physical Elements of Geography (appropriate sections on climate).

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 26. The Nature, Properties and Geographic Distribution of Soils (Russell)

The soils that form a thin mantle over the land surface of the earth are natural geologic bodies that have developed under a wide range of climates and from diverse parent materials. The term soil is applied to the upper part of the regolith which has been subjected to significant biochemical weathering. Hydrolysis, hydration, oxidation, carbonation, and solution accompanied with a pronounced increase in interfacial area of the solid phase are the major features of the physico-chemical weathering leading to soil formation. The weathering is accompanied by biological processes and the accumulation of organic matter. The translocation of weathering products accompanied by deposition and resynthesis results in the development of layers or soil horizons having distinctive properties. Soils are classified on the basis of the occurrence and properties of the several horizons which comprise the soil profile.

The principal factors that govern the soil forming processes and thereby determine the nature and properties of the soil formed are: parent material, climate, vegetation, topography, and time. Through the interaction of these factors, soils are formed which differ widely from place to place. On a broad scale climate is perhaps the most important factor affecting soil development. This is reflected in the similarity in geographic distribution of the Great Soil Groups and the major climatic regions of the world. Local differences of soils arise more from the interplay of the differences in the other four factors.

The soil is a porous body composed largely of inorganic particles with variable amounts of organic constituents. The voids between the solid particles are filled with reciprocally varying amounts of water and air. The inorganic particles which comprise roughly fifty per cent of the bulk volume of most soils range widely in size and are conventionally classified as sand, silt, or clay. The mineral fraction is composed primarily of alumino-silicate minerals, with iron and the alkaline earth elements as the major substituted bases. The finely-divided mineral fraction commonly called clay is composed of highly hydrated alumino-silicates having a micaceous form and high physicochemical reactivity.

The organic fraction of the soil varies between wide limits but is usually of the order of two to five percent in the surface horizon of cultivated

Lecture 15. *The Nature, Properties and Geographic Distribution of Soils* ([illegible])

The soils that form a thin mantle over the land surface of the earth are natural geologic bodies that have developed under a wide range of climates and from diverse parent materials. The term soil is applied to the upper part of the regolith which has been subjected to significant bio-chemical weathering. Hydrolysis, hydration, oxidation, carbonation, and solution accompanied with a pronounced increase in interfacial area of the solid phase are the major features of the physico-chemical weathering leading to soil formation. The weathering is accompanied by biological processes and the accumulation of organic matter. The translocation of weathering products accompanied by deposition and resynthesis results in the development of layers or soil horizons having distinctive properties. Soils are classified on the basis of the occurrence and properties of the several horizons which comprise the soil profile.

The principal factors that govern the soil forming processes and thereby determine the nature and properties of the soil formed are: parent material, climate, vegetation, topography, and time. Through the interaction of these factors, soils are formed which differ widely from place to place. On a broad scale, climate is perhaps the most important factor affecting soil development. This is reflected in the similarity in geographic distribution of the Great Soil Groups and the major climatic regions of the world. Local differences of soils arise more from the interplay of the differences in the other four factors.

The soil is a porous body composed largely of inorganic particles with variable amounts of organic constituents. The pores between the solid particles are filled with continuously varying amounts of water and air. The inorganic particles which comprise roughly fifty per cent of the bulk volume of most soils range widely in size and are conventionally classified as sand, silt, or clay. The coarser fraction is composed primarily of alumino-silicate minerals, with iron and the alkaline earth elements as the major substituted bases. The finely-divided or clay fraction commonly called clay is composed of highly hydrated alumino-silicates having a micaceous form and high physico-chemical activity.

The organic fraction of the soil varies between wide limits but is usually of the order of two to five per cent in the surface horizons of cultivated

soils of temperate regions. It is composed of the decomposing tissues of plants and animals with the major portion or humus present as a slowly metabolizing colloidal ligno-protein complex. Soil organic matter modifies the physico-chemical behavior of the inorganic soil components, serves as an energy and nutrient source for the soil micro-organisms, and is a reservoir for nitrogen and other essential nutrients for higher plants.

The liquid phase is a highly dynamic part of the soil usually occupying from 10 to 35 per cent of the bulk volume of most soils. It is a dilute aqueous solution containing cations which are in dynamic equilibrium with similar ions absorbed on the surface of the soil particles. The liquid phase is the habitat for the soil micro-organisms and is the medium for transport of ions and weathering produced within the soil. Because of the dipolar character of the water molecule and its tendency to form H-bonds with electron-rich surfaces, water is a dominant factor in all of the physical reactions occuring in the soil.

The gaseous phase of the soil is similar to the atmosphere except that it is normally saturated with the water vapor and usually contains 10 to 100 times as much CO_2 and slightly less oxygen. Molecular diffusion is the principal mechanism involved in the interchange of gases between the soil voids and the atmosphere. When soil voids are absent or waterfilled, anaerobic conditions are created which significantly alter the chemical and biological reactions of the soil and impair the growth and functioning of plant roots present in the poorly aerated soil.

The soils of the world may be classified into the following seven groups:

1. Soils of the cold zone – the tundra soils -- these occur at high latitudes and are of little agricultural importance. Biological and chemical weathering are minimal and the substrata is often permafrost. The accumulation of organic matter gives a peaty surface often overlying poorly oxidized blue-gray sticky subsoil. Drainage is poor and surface irregularities caused by alternate freezing and thawing are common.

2. Light-colored podzolized soils of timbered regions. This is a large group of soils including the podzols, Brown and Gray-Brown Podzolics and Red and Yellow Podzolics. The process of acid leaching called podzolization is the dominant soil-forming factor in these soils of the humid mid-latitudes. Bases are removed from the surface horizons creating a bleached ashy A_2 layer and iron and aluminum secondary minerals and hydrogels are accumulated in the subsurface horizons.

3. Soils of forested warm temperate and tropical regions. Severe hydrolysis and oxidation result in destruction of the silicate minerals in a process known as latosolization. Iron, aluminum and manganese oxides and hydrates remain and may form cemented horizons called laterite. Latosols are very low in bases but often have good physical properties even when very high in clay.

soils of temperate regions. It is composed of the decomposing tissues of plants and animals with the major portion or *humus* present as a slowly metabolizing colloidal ligno-protein complex. Soil organic matter modifies the physico-chemical behavior of the inorganic soil components, serves as an energy and nutrient source for the soil micro-organisms, and is a reservoir for nitrogen and other essential nutrients for higher plants.

The liquid phase is a highly dynamic part of the soil usually occupying from 15 to 35 per cent of the bulk volume of most soils. It is a dilute aqueous solution containing cations which are in dynamic equilibrium with similar ions absorbed on the surface of the soil particles. The liquid phase is the habitat for the soil micro-organisms and is the medium for transport of ions and weathering produced within the soil. Because of the dipolar character of the water molecule and its tendency to form H-bonds with electron-rich surfaces, water is a dominant factor in all of the physical reactions occurring in the soil.

The gaseous phase of the soil is similar to the atmosphere except that it is normally saturated with the water vapor and usually contains 10 to 100 times as much CO_2 and slightly less oxygen. Molecular diffusion is the principal mechanism involved in the interchange of gases between the soil voids and the atmosphere. When soil voids are absent or waterfilled, anaerobic conditions are created which significantly alter the chemical and biological reactions of the soil and impair the growth and functioning of plant roots present in the poorly aerated soil.

The soils of the world may be classified into the following seven groups:

1. *Soils of the cold zone* – the tundra soils -- these occur at high latitudes and are of little agricultural importance. Biological and chemical weathering are minimal and the substrate is often permafrost. The accumulation of organic matter gives a peaty surface often overlying poorly oxidized blue-grey sticky subsoil. Drainage is poor and surface irregularities caused by alternate freezing and thawing are common.

2. *Light-colored podzolized soils of timbered regions.* This is a large group of soils including the podzols, Brown and Gray-Brown Podzolics and Red and Yellow Podzolics. The process of acid leaching called *podzolization* is the dominant soil-forming factor in these soils of the humid mid-latitudes. Bases are removed from the surface horizons creating a bleached ash-like layer and iron and aluminum secondary minerals and hydroxyls are accumulated in the subsurface horizons.

3. *Soils of forested warm-temperate and tropical regions.* Severe hydrolysis and oxidation result in destruction of the silicate minerals in a process known as *laterization*. Iron, aluminum and manganese oxides and hydroxides remain, and may even cement to form masses called *laterite*. Laterites are very low in bases but often have good physical properties even when very high in clay.

4. Dark-colored soils of semi-arid, sub-humid and humid grasslands. The chernozems, brunizems and chestnut soils--the dominant soil forming process is calcification. The leaching occurs at neutral to alkaline pH levels and the divalent cations are not removed from the profile. A zone of $CaCO_3$ accumulation occurs at a depth approximating the average penetration of rain water. Soluble salts of sodium and potassium may occur at lower depths in the drier parts of the region.

5. Light-colored soils of arid regions. Sierozems, Red desert and Brown soils. These soils are developed under very low rainfall. $CaCO_3$ accumulates at or near the surface and soluble salts of sodium and potassium occur at shallow depths. Organic matter accumulation is low. Severe cementation or caliche layers are common.

6. Intrazonal soils. These are soils whose characteristics are dominated by some local feature so that they are atypical of the normal soils of that geographic region. The hydromorphic or bog soils are dominated by excessive moisture with the consequent accumulation of organic matter and poorly ozidized or glei subsoils. The planosol or claypan soils of south central Illinois also are intrazonal because of their atypical hydrology. The halomorphic or salty soils of the subhumid and semi-arid regions are dominated by the presence of high concentrations of sodium, potassium, or magnesium bicarbonates, sulphates, or chlorides. The process operating is called salinization. Excessive lime may yield black soils called rendzinas or in the humid forested regions brown forest soils.

7. Azonal soils. These are soils whose properties are determined largely by the parent material on which little or no soil formation has occurred. Included in this category are the lithosols, regosols, and the alluvial soils. The latter are of great agricultural importance.

In summary we can say that the soil is a natural body occurring at the interface between the earth's crust and the atmosphere. It is formed by bio- and physio-chemical weathering of the regolith and results from the dynamic interaction of the parent material, climate, vegetation, topography, and length of the weathering periods. The characteristics and processes of soils are dominated by physical, chemical, and biological reactions which occur in large measure at the solid-liquid interfaces present in the soil. Thus the soil may be considered as an integral part of man's ecosystem. Its role in the production of food will be discussed in the next lecture.

Required References

Kellogg, C. E. The Soils that Support Us.

Lyon, Buckman, and Brady. The Nature and Properties of Soils.

USDA 1957 YEARBOOK: Soils.

4. Dark-colored soils of semiarid and subhumid grasslands. The chernozems, brunizems and chestnut soils - are examples showing varying degrees in calcification. The decreasing amount of organic matter and the depth of the dark colored surface horizon are noted as rainfall decreases. Accumulation of calcium occurs at a depth corresponding to the average penetration of soil water. Soluble salts of sodium and potassium may occur at some depth in the drier parts of the region.

5. Light-colored soils of arid regions. Sierozems, red desert and brown soils. These soils are developed under sparse vegetation. Organic matter accumulates only in small amounts and calcium carbonate accumulates at shallow depths. Organic matter accumulation is low. Saline concentrations or caliche layers are common.

6. Intrazonal soils. These are soils whose characteristics are dominated by some local feature so that they are atypical of the general soils of that geographic region. The hydromorphic or bog soils are dominated by excessive moisture and poor drainage; calcimorphic soils are dominated by limestone parent materials. The halomorphic or salty soils of the semiarid and arid regions are dominated by the presence of high concentrations of sodium, potassium, or magnesium bicarbonates, sulfates, or chlorides. The process operating is called salinization. Examples of these are solonchak and solonetz soils, or in the humid forest regions planosol soils.

7. Azonal soils. These are soils whose properties are determined largely by the parent material on which they are formed and are little developed. Included in this category are the lithosols, regosols, and the alluvial soils. The latter are of great agricultural importance.

In summary, we can say that the soil is a complex and ever changing interface between the earth's crust and the atmosphere. It is formed by chemical and physical weathering of the crust and is derived from the dynamic interaction of the parent material, climate, vegetation, topography, and length of weathering periods. The characteristics and distribution of soils are determined by physical, chemical, and biological reactions and the large numbers of organisms present in the soil. Thus the soil may be considered as an integral part of many ecosystems. Its role in the production of food will be discussed in the next lecture.

Required Reading

Kellogg, C. E. The Soils that Support Us.

Lyon, Buckman and Brady. The Nature and Properties of Soils.

USDA 1957 Yearbook: Soil.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 27. The Soil as a Medium for Plant Growth (Russell)

Terrestrial plants depend on the soil for nutrient elements and the water that they require for growth. In addition, higher plants require a source of CO_2, light, and suitable ambient temperature conditions. The major nutrient elements supplied by the soil are nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur, with lesser amounts of iron, boron, manganese, zinc, copper, and molybdenum.

Although most of these elements are present in substantial quantities in the minerals found in soil they may not be available for plant use because of the chemical or crystalline form in which they occur. To be absorbed by plant roots the nutrient ions must either be present in the soil solution or as exchangeable ions on the surface of the solid phase soil components. The capacity of the soil to hold ions in such an exchangeable form is one of its most important properties. In acid soils the exchange sites are dominated by H^+ and Al^{+++} rather than by the more useful Ca^{++}, Mg^{++} and K^+ ions. Such deficiencies may be corrected by liming and fertilization.

The ability of soils to supply nitrogen for higher plants is largely associated with the biological transformations of the soil organic matter. Soil micro-organisms break down to ammonia the complex nitrogen compounds of dead plant and animal tissues that become incorporated into the soil. The ammonia is either absorbed directly or is oxidized to the nitrate form by the soil bacteria and then taken up by plant roots. A significant part of the phosphorus used by plants also is made available through the organic matter cycle.

The soil also serves as a short-term storage facility for the water required by growing plants. Even in humid regions the intermittent rainfall does not coincide with the steady use of water by actively transpiring plants. Through the mechanism of storage in the soil the discontinuous water supply can be modulated to meet the steady water demand of the plant. The capacity of the soil to store water in a form usable by plants is related to the depth and porosity of the soil and to its affinity for water. The ease with which water can move through the soil also is important in determining how effective the soil will be in modulating the water supply.

In their natural state soils differ widely in productive capacity. It is important to recognize, however, that productive capacity is subject to

[illegible]

[illegible]

Lecture [illegible] The Soil as a Medium for Plant Growth: [illegible]

The [illegible] and the water that [illegible]. [illegible] The major nutrients [illegible] phosphorus, potassium, [illegible] magnesium, and [illegible] boron, [illegible] copper, and molybdenum.

Although [illegible] in the [illegible] the chemical [illegible] plants [illegible] The [illegible] Such [illegible].

The [illegible] largely associated with the [illegible] phosphorus [illegible] the soil [illegible] cycle.

The soil [illegible] Through the [illegible] of the soil [illegible] and [illegible] the [illegible].

[illegible] important to [illegible].

modification by suitable cultural practices. Corrective measures include liming, fertilization, use of legumes, drainage, subsoiling, terracing, irrigation, fumigation, etc. However, little can be done on a practical field scale to change the basic physical and physico-chemical constitution of the soil except by slow changes in the amount and depth distribution of organic matter.

The total land surface of the earth is roughly 32×10^9 acres but only about seven and one-half percent is cultivated and an additional seven and onehalf per cent is used for permanent meadows and grazing. A general view of the world's land indicates that about half of it is unsuited for cultivation. This includes the tundra, the high mountains and the major desert regions. Much of the remaining half is stony, sandy, hilly, salty, or too wet, but could be utilized with appropriate technology. Most of the good land in the humid temperate zones is now under cultivation although much of it could be used more intensively. Much of the northern Podzol region is sparsely used and cultivation could be expanded considerably in these regions despite serious climatic limitations.

The major areas of undeveloped soil are in the tropical regions of Africa, South and Central America, Southeast Asia, and some of the major islands of the Southwest Pacific. The potential area for cultivation in the tropics probably exceeds the combined present cultivated acreage of the United States and the USSR. Tropical soils are, in general, highly weathered and low in nutrient elements. Their virgin productivity stems from the fact that the essential nutrient elements are kept continuously in the biotic cycle. The low nutrient retention capacity of tropical soils makes necessary an agricultural technology that minimizes the escape of nutrients from the system.

Expansion of cultivation into semi-arid and desert regions through the use of irrigation requires a dependable supply of high quality water, suitable terrain, and adequate subsurface drainage to prevent the accumulation of soluble salts. Some of the technical and socio-economic problems of an irrigated agriculture will be discussed.

In a general sense, soil may be considered as a renewable natural resource. It serves as a "staging area" for the nutrients and water needed for crop production. Soil productivity is subject to modification by the application of technology which makes possible the correction of basic deficiencies of the soil as a plant growth medium. Through the application of such technology, soil management and crop production become more intimately dependent on the whole economic and cultural system.

Required Reading

Kellogg, C. E., The Soils that Support Us.

Lyon, Buckman, and Brady. The Nature and Properties of Soils.

USDA 1957 YEARBOOK: Soils.

USDA Misc. Pub. #705, 1949. A Graphic Summary of World Agriculture.

Kellogg, C. E. (UNESCO REPORT). Food, Soil and People.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 28. Agricultural Ecology - Tropical Subsistence Agriculture (Booth)

The humid tropical environments here considered are areas with either the tropical rainforest or the tropical wet-and-dry type of climate, with a range of native vegetation from two-story rainforests through single-story rainforests, light tropical forests, and park savannas to savannas and with a range of mature soils from true latosols to reddish or degraded chernozems. Such immature soils as alluviums, volcanic, rendzinas, organic, and lithosols have some special significance in these agricultural environments.

Several criteria may be utilized in distinguishing agricultural systems. A primary criterion is related to the disposal of the products of agriculture. A general subdivision of agriculture types on this basis is a division into subsistence and commercial. Subsistence agriculture may further be divided into shifting and sedentary. Beyond this point such factors as the basic tools used (dibble stick, hoe, plow), the basic crops produced (root, cereal, tree), the use of animals, the use of fertilizers, the extent of irrigation, the patterns of fields and settlements, and others may be utilized in establishment of further categories. In the present instance, a subdivision of shifting agriculture into nomadic and non-nomadic types and of sedentary into garden, dry field, and wet field types will be utilized.

Shifting Agriculture - Shifting agriculture, often referred to as fire agriculture, because of the almost universal use of fire as an aid to clearing land, may represent the original form of agriculture. The usual steps in this system involve the girdling or cutting of trees, the burning over of the land, the planting of seeds with the aid of the dibble stick, the guarding of the growing crop, the harvesting of the crop, and the abandonment of the land. The universitality of this system is suggested by the inclusion of the name of this system in the language of nearly all areas where it is or has been practiced. Disadvantageous features of this system include low productivity, often devastating deforestation and soil erosion, and the encouragement of primitive social and political organizations.

Sedentary Agriculture, Garden Type - The evolution from shifting to sedentary agriculture is most often brought about by population pressure or governmental controls. One of the three forms of sedentary agriculture is garden culture. In this form the most desirable and adaptable plant species are concentrated either by elimination of undesirable species or the planting of desirable species in small plots usually directly adjacent to the settlement

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369,
Physiology 369, Soil Science 369, Veterinary Science 369, and
Zoology 369)

Lecture 33 - Agricultural Ecology - Tropical Subsistence Agriculture (Bennett)

The humid tropical environments have considered are areas with either the tropical rainforest or the tropical wet-and-dry type of climate, with a range of natural vegetation from two-story rainforests through single-story rainforests, light tropical forests, and park savannas to savannas and with a range of soils from true laterites to latosols or degraded chernozems. Such immature soils as alluvium, volcanic, limestone, organic, and lithosols have some special significance to these agricultural environments.

Several criteria may be applied in distinguishing agricultural systems. A primary criterion is related to the disposition of the products of agriculture. A general subdivision of agriculture types on this basis is a division into subsistence and commercial. Subsistence agriculture may further be divided into shifting and sedentary. Beyond this point, criteria are the basic tools used (digging stick, hoe, plow), the basic crops produced (grain, root, tree), the use of animals, the use of fertilizers, the extent of irrigation, the size and types of fields and settlements, and others may be involved in establishment of further categories. In the present instance, a definite aim of studying agriculture with domestic and subsistence types and of sedentary into garden-ery (and) the most typical village culture.

Shifting Agriculture - Shifting agriculture, often referred to as the cultivation version of the slash-and-burn, the Filipino caingin, or the Ceylon chena, land, must represent the original form of agriculture. The usual steps in this system include the clearing or cutting of trees, the burning over of the land, the planting of seeds with the aid of the dibble stick, the cultivation of the growing crop, the harvesting of the crop, and the abandonment of the land. The universality of this system is suggested by the multiplicity of the names of this system in the languages of peoples who have practiced it. Shifting cultivation is a system of low productivity, often accelerating deforestation and soil erosion, and the encouragement of grassland and similar type vegetations.

Sedentary Agriculture, Garden Type. - The transition from shifting to sedentary agriculture is brought about by population pressure or governmental controls. One of the lowest forms of sedentary agriculture is garden culture. In this form the most important and valuable plant species are concentrated either by transplantation or by selective planting of the seedling of desirable species in small plots usually directly adjacent to the settlement

units. A three-story arrangement consisting of root crops, bush and vine crops, and tree crops often result in continuous harvesting cycle. Under western influence commercial tendencies are developed in this system.

Sedentary Agriculture, Dry Field Type - Continuous cropping of the same parcel of non-alluvial, non-irrigated land offers one of the most difficult problems of tropical agriculture. Only if there are unusual physical circumstances or if exceptional care is taken of the land does this permanent system of agriculture prove successful. Volcanic or limestone-derived soils on gentle slopes, agricultural practices which include, amongst others, the use of the plow, the rotation of crops, and the rearing of animals, as well as a stable population, are amongst the usual ingredients of this system.

Sedentary Agriculture, Wet Field Type - The most productive system of subsistence agriculture which has been developed in the humid tropics is the one which centers about the production of paddy or wet field rice. This system implies the use of flat land with small leveled fields which have been diked to hold the water required in rice growth. The water may be derived from normal precipitation, from stream flooding, from a system of irrigation, or from some combination of these three water sources. The human labor requirements of this system during the growing season are great. The leveling of fields, the construction of dams or dikes, the construction or maintenance of terraces, the preparation of the fields, the transplanting of the crop, the application of fertilizer, the cultivation of the fields and the harvesting of the crop are all done traditionally with only the simplest of tools and without too much use of animal power.

Required References

Ginsburg, Norton, The Patterns of Asia.

Pelzer, Karl J., Pioneer Settlement in the Asiatic Tropics.

Tothill, J. D., Agriculture in the Sudan.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 29. Agricultural Ecology - Agriculture of the Indian Subcontinent (Booth)

All of the various types of tropical subsistance agriculture are found in the Indian Subcontinent. This variety is related in part to a great diversity of physical environments. Landforms vary from major mountain systems to small alluvial plains; vegetation associations from rainforest to desert; zonal soils from latosolic to tundra; and climate from tropical rainforest to icecap. For present purposes four fundamental environments based largely on rainfall considerations may be recognized. These are, the very wet (over 80"), the wet (40"-80"), the dry (20"-40"), and the very dry (less than 20"). In the very wet areas, collecting and gathering, shifting agriculture, the sedentary garden type, and the sedentary wet field type are all practiced. In the wet areas both sedentary wet field and sedentary dry field, as well as some shifting agriculture, are practiced. In the 20"-40" zone the dry field type is dominant except where potentials for irrigation exist. In the dry zone, irrigation agriculture is the dominant type.

In the wet Ganges Delta Land variations in soil types and extent of flooding are major factors in crop ecology. Cropping potentials in turn explain variations in agricultural systems and population densities. In the upper delta are broad areas of older alluvium no longer flooded upon which have been developed latosolic soils. These essentially flat-topped doabs are not utilized agriculturally and are covered by almost useless scrub and degraded remnant forests. By contrast the valleys of the active streams which cut across these doabs are in continuous paddy cultivation. Lower in the delta the depth of flooding (along with soil types) plays an important role in crop determination. Thus on the high levels with sandy soils garden crops and a quick maturing variety of rice occupy the land. On the long slopes of levels with loamy soils where from 5 to 15 feet of water accumulate is found the best rice and the cash crop, juta. In the clayey marshey lowland cropping is only possible during the winter season.

The Maleoan Coast of southeastern India also exemplifies environmental variations and concurrent cropping variations. Along the immediate coast are the sandy offshore bars and beach ridges with intensive garden culture based upon coconut palm production. Inland of the bars are partially filled lagoons and interspersed alluvial aprons. A watery environment perfectly adapted to paddy rice cultivation. Next are the flanning low terraces and spurs of the Western Ghats which are devoted to dry rice and root crop production. Finally inland are the slopes of the Ghats given over at lower

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology [illegible], Geography [illegible], Health Education [illegible], Physiology 359, Sociology [illegible], Veterinary Science [illegible], and Zoology [illegible])

Lecture [illegible]. Agricultural Ecology - Agriculture in the Indian subcontinent (South)

All of the various types of tropical subsistence agriculture are found in the Indian subcontinent. This variety is related in part to a great diversity of physical environments. Landforms vary from major mountain systems to small alluvial plains, vegetation associations from rainforest to desert, and soils from lateritic to tundra; and climate from tropical rainforest to tundra. For present purposes, four fundamental environments based largely on rainfall considerations may be recognized. These are, the very wet (over 80"), the wet (40"-80"), the dry (20"-40"), and the very dry (less than 20"). In the very wet areas, collecting and gathering, shifting agriculture, the sedentary garden type, and the sedentary wet field type are all practiced. In the wet areas both sedentary wet field and sedentary dry field, as well as some shifting agriculture are practiced. In the 20"-40" zone the dry field type is dominant except where conditions for irrigation exist. In the dry zone, irrigation agriculture is the dominant type.

In the wet Ganges Delta local variations in soil types and extent of flooding are major factors in man ecology. Cropping patterns reflect minute variations in agricultural systems and population densities. In the moribund delta the broad natural levees, having no longer flooded upon their back slopes, have developed lateritic soils. These essentially flat-topped doabs are not utilized agriculturally and are covered by almost wild scrub and degraded remnant forests. By contrast the valleys of the active streams and of the doabs, these doabs are in continuous paddy cultivation. Except in the delta the depth of flooding (along with soil types) plays an important role in agricultural ecology. Thus on the high levees with sandy soils garden crops and a great variety of tree crops occupy the land. On the long slopes of levees with loamy soils where from 4 to 12 feet of water accumulates is found the deep water rice and the cash crop, jute. In the deeper, marshier lowland swamps no crop is possible during the winter season.

The Malabar Coast of southwestern India has conspicuous environmental variations and concurrent cropping variations. Along the immediate coast are the sandy offshore bars and beach ridges with dense garden culture based upon coconut palm production. Behind of the bars are extensive lagoons and recent alluvial plains, a watery environment perfectly adapted to paddy rice cultivation. Next are the flanking low laterite spurs of the Western Ghats which are devoted to dry rice and [illegible] production. Farther inland are the slopes of the Ghats given over to forest.

elevations to plantation agriculture and to shifting agriculture and primitive gathering and collecting at higher elevations.

In the Western portion of peninsular India is a large area of bedrock consisting of layer upon layer of basaltic lava flows. Upon this has developed the distinctive regur soil. These self-fertilizing, sticky, water-retentive soils are the bases of a distinct and unusual double crop system of dry agriculture in an area of a single season of modest rainfall.

Required Readings

Ginsberg, Norton. Patterns of Asia

Spate, India and Pakistan

Rawson, The Monsoon Lands of Asia

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369,
Physiology 369, Sociology 369, Veterinary Science 369, and
Zoology 369)

Lecture 30. Agricultural Ecology: The European Peasant Economy (Booth)

The physical environment of northwestern Europe derives its greatest unity from the prevalence therein of the Marine Westcoast type of climate. The greatest diversity is associated with the landforms and soils elements of the landscape. Climate is featured by mild winters, cool summers, and very adequate (20"-40"), well distributed rainfall. Daylight hours are long in summer (16-20), but extensive and prolonged cloud cover reduces sunshine. The basic forest association is deciduous broadleaf but mixed deciduous and coniferous, and coniferous association and scrub or heath associations are found in unfavorable climatic, edaphic, and landform sites. Nearly all non-dry climate landforms from ancient crystalline mountains to young folded mountains and from structural plains to various types of depositional plains are represented in Europe. Although the grey-brown podzolics are the basic soils group the widespread prevalence of gradational activity associated with a wide range of earth materials has produced a situation of great pedalogical variety.

From the agricultural ecological standpoint both climatic and edaphic factors are determinants of critical crop boundaries. Most significant are the 32° F. mean monthly temperature for the coldest month, the 60° F. mean monthly temperature for the warmest month, (northern limit of oaks), and the boundaries of sandy soils, heavy clay soils, and organic soils. These have been selected as critical since they are related to the ecology of such cereals as wheat, barley, rye, and oats, to root crop production, and to production of various associations of forage crops, and to the ecology of domestic animals chiefly cattle, sheep, and hogs.

Wheat cropping requires the areas of better soils and milder winters, barley and oats are more tolerant of less favorable soils and climate, while rye tolerates acid sandy soils and cold winters. Potatoes and sugar beet, both introduced into Europe in the Seventeenth Century, are the most important root crops with high caloric yields. Pasture has an almost year round growing season and supports an important cattle raising industry, primarily for dairy produce. Hogs were formerly raised on forage in the oak and beech forests, but are now associated with farms and utilize dairy and cereal wastes. Sheep graze the upland grasslands and heather.

The distinctive characteristic of peasant agriculture is the attachment of the man to the land in a self-employment situation where labor is more

[illegible]

Lecture 31. [illegible] (Smith)

The [illegible] its greatest [illegible] climate. The [illegible] of the [illegible] and [illegible]

[illegible]

[illegible]

The [illegible] of the [illegible]

important than capital. Usually implied in this relationship is essential self-sufficiency. Long father-to-son or family continuity, and relatively small farm holdings. Normally, farm hamlets and communal cooperativeness are also considered to be part of the general picture. Variations from these norms in Europe were widespread, some to be explained in social terms, others in terms of variations in physical environment.

The use of the plow, integrated animal husbandry, and crop rotation are the basic practices which generally distinguish western European peasant agriculture from tropical or oriental peasant agriculture. The basic types of agriculture are the slash-and-burn, the infield-outfield, and the familiar three-field system. As agriculture becomes more intensive forests, pastures and meadows, and fallow land occupy smaller and smaller proportions of the farm land.

Required Readings

Hoffman, Geography of Europe

Thomas, Man's Role in Changing the Face of the Earth, pp. 183-277.

important than capital. Usually implied in this relationship is essential self-sufficiency. [illegible] economy, and [illegible], small farm holdings. Normally, farm hamlets and [illegible] are also considered to be part of the general picture. Variations from area to area in Europe [illegible], some to be explained in social terms, others in terms of variations in physical environment.

The use of the plow, [illegible] animal husbandry, and crop rotation are the basic practices which presently distinguish western European peasant agriculture from 'typical' or 'normal' peasant agriculture. The basic types of agriculture are the [illegible], the infield-outfield, and the familiar three-field system. [illegible] agriculture becomes more intensive as cereals, pastures and meadows, and [illegible] occupy smaller proportions of the farm land.

Required Readings

Hoffman, *Geography of Europe*.

Thomas, *Man's Role in Changing the Face of the Earth*, pp. [illegible].

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 31. Commercialized Agriculture (Russell)

The industrial revolution has been accompanied by major changes in agriculture. The development of transportation systems, the great increase in per capita power supply, and the application of science and technology to the processes involved in meeting the basic human needs for food and shelter have made it possible to reduce to less than ten per cent the portion of the population needed to produce the food and fiber required by the total population.

Present day industrialized agriculture is a highly specialized component of a complex interdependent economic and cultural system. There is a great flow of production inputs and products into and out of each specialized component of this interdependent complex; hence, no farm, no community, nor in fact no region or nation operates as a wholly self-sufficient unit. Local or regional specialization may occur as a means of maximizing local or regional ecological conditions, although political or economic factors may override such specialization.

Plantation Agriculture - This is a highly specialized type of monoculture confined largely to tropical or semi-tropical regions. It is characterized by large operating units, with centralized professional management, hired labor, usually a corporate structure involving absentee ownership and often involving post-harvest processing of the crop. Crops having long growing seasons requiring more or less steady labor inputs are best suited for this type of agriculture. Contrasting examples of plantation agriculture will be discussed including coffee, sugar cane, pineapple, and rubber.

Midwestern Corn-Belt Agriculture - This is a highly efficient agriculture consisting primarily of one-man operating units. Capital and technology are being substituted for labor at a rapid rate. Production efficiency per man has increased more than 50 per cent in the past 20 years. There is a growing tendency towards monoculture or single enterprise specialization. Management skills rather than manual skills are needed for success. The role of cooperatives, "vertical integration", professional services and governmental policies and programs as factors affecting farming operations will be discussed. Comparisons are made with the collective and state farms of the USSR.

INTRODUCTICN TC HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

To Follow Lecture 31. The Pastoral Nomads of Asia: Ecology of the Turks and Mongols (Lawrence Krader*)

The name of a culture, Tartar, and of a realm, Tartary, has been in use for two thousand years. The provenience of the word is unknown, but during the first five centuries A.D. it was used by Mongols and Turks in the interior parts of Asia as a name for certain tribes or peoples of their number. It appears in Turkic inscriptions of the 6th-8th centuries. During the 9th and 10th centuries, the Chinese began to refer to the Turks and Mongols collectively as T'a-t'a-erh. The term and the general referent were introduced into Europe by 13th century travellers. Both the oriental and the occidental traditions have thus designated Turco-Mongol pastoral nomads inhabiting the territory between the south Russian steppe and the Great Wall of China.[1]

The cultural unity of this cultural world was early established by the indigenous peoples themselves, and soon after recognized by their neighbors to east and west. Today, the historical unity is but dimly perceived, and appears to be permanently disrupted. Political factors, the entry of China and Russia as decisive forces in the region, have contributed to the disruption; and specialists, who write in the guise of scientists, have raised dust as well.

We will consider the pastoral Turks and Mongols as two great wings of a single culture related by bonds of language, history, and polity; the framework of this relationship is a common environment, whcih will be described in some detail. Their adaptation to this environment, and their adaptation of it is shared, based on the raising of complex herds of sheep, goats, cattle, horses, camels, and in certain places also yaks, asses and mules. Their communities are mobile villages of agnatic kin; they live in tents and move with their herds as nomads. Some three millenia ago they achieved a high degree of success in this adaptation, and maintained it with little change until the present period when the pastoral nomads are found only in small pockets here and there. Our task will be to pierce through the recent changes and observe the relationship between the ecological and cultural area. The imperceptibility of cultural change over much of the period may give the impression of a static human ecological system. This impression must give way to the consideration of a dynamic ecological system.

*Based on lecture sponsored by Biological Sciences Lecture Committee and Center for Russian Language and Area Studies, May 24, 1961.

Some understanding of the geographic processes in the area may be gotten by considering problems of delimitation. The interior parts of Asia extend from the Great Hsingan Range of Western Manchuria to the Caspian Sea, forming the eastern expanse of the arid zone of the Old World. The central and western expanses are respectively, southwest Asia and North Africa. The eastern region comprises the two Mongolias, Inner and Outer, and the three Turkestans, Chinese, Russian, and Afghan, - our domain of Tartary, the Asian interior.

The entire region is circumscribed by an isohyet of 300mm. Within this territory, the mean annual precipitation is less than this sum, except in the vicinity of mountains. Far removed from either Atlantic or Pacific atmospheric circulations, the region is without access by water to the sea: the valleys of the Irtysh, the Onon and Kerulen, which at their confluence form the Amur, and the Huang-ho, form the periphery of the macro-zone which, for this reason, may be called Inland Asia.

Of the physical features, those that relate to water are of primary human concern: distance from the oceans, distance from oceanic atmospheric circulations, low mean annual precipitation, lack of outlet to the sea. Climatologically, in addition to the aridity and circulation factor, the region has great amplitude of temperatures, little cloudiness, maximum insolation, and strong wind action. In consequence of these factors, soil erosion and the effect of dust and scale formation on machinery are problems throughout the region.

The flora have a poverty of genera; they include Stipas, feathergrass of the steppe and semidesert, and Agrophyrum, especially A. repens, a desert grass. The fauna are rich in ungulates. The distribution of these biota are of cultural significance.

Characteristics of the Ecology of Pastoral Nomads

Definition of terms

Pastoral nomadism is the pattern resultant from the coalescence of independent traits, nomadism and pastoralism. Nomadism is a periodic cyclical movement of certain faunal species, many of which have been domesticated by man; the cycle takes place in a unitary time period, and is closed by return to the point of origination. Nomadism is distinct from wandering, movement which can only with difficulty be submitted to a program within a territory; it is sometimes confused with wandering, and with transhumance, both in popular usage and in the ethnographic literature.

Pastoralism is practiced by other peoples than nomads: sedentary farmers, and peoples who are tradesmen as well as herdsmen, such as Gypsies and Vlachs (the objects of the study of Wace and Thompson) for

example. Pastoral nomads, in contrast to these peoples have either an exclusive or principal reliance on animal-raising for their support, supplemented by hunting, and in the case of certain Turkic groups, by winter-camp farming.

Human ecology embraces the study of adaptations to the environment and adaptations of the environment. Let us consider these relationships seriatim in connection with the Tartar nomads. Their culture has evolved a number of adaptations to their environment: they are tent-dwellers, which facilitates movement; their movement is cyclical, a further adaptation of the same sort. They do nothing to replenish the grass which feeds the herds. Water holes, the shallow currents of the spring season, and natural springs, are trampled into brackish wastes during the moves by the herds, and are unhealthy for man and beast to drink. The water holes and courses will take a year to re-form, and the grass to grow again. Bergmann, who travelled among the Kalmuks first made these observations in 1802 and 1803; they were confirmed by my observations of the Kashkai of Iran in 1958.

Seasonal water courses and seasonal florescence in the Bet-pakdala or Hungry Steppe and in Dzungaria allow traverse in the spring and early fall, to which the nomads and their herds conform. Their cyclical movement and annual period are conditions of these environmental factors.

The cycle is divided into segments, either two or four pasturings a year. Summer and winter termini are the constant features of the nomadic pattern throughout the culture area; whether spring and fall pasturing is practiced is a variable, from tribe to tribe and from place to place. The movement is subject to rigorous controls; not only the pastures but the tracks which link them are "owned," that is, assigned by customary right among the herding kin communities. Occupancy of pasture or use of track by other than those who enjoy the customary right is invasion; to which there are two modes of response: retaliatory raids and highly complicated arbitration.

Technological and legal devices mentioned so far are primarily adaptations to the environment. But the pastoral nomads are not simple or primitive cultures. They are moderately advanced; convenient and a bench-mark of their advanced state is the number of arrangements they have devised in the management of complex herds. Our task in the elucidation of this point is rendered the easier today by the ecological commentaries made 20 years ago by Julian Steward[2], who wrote: "The extent to which ecology conditions and delimits culture depends on the culture. In primitive societies it predetermines and delimits certain features. The more complex societies have more complex solutions." Steward's classifications in the

1930s of ecologically simple and complex societies were based on observations of hunters and gatherers of the Basin and Plateau of the American west: primarily Ute and Paiute. Compared with this baseline, the Turks and Mongols are far from primitive. And, they are not as advanced as their agricultural neighbors, the Persians or Chinese. They have adapted to certain features of the environment: they have adapted others to their own ends. Several measures for the scale of primitive to complex cultures are applicable in human ecology. One of these is the kind and degree of control of the environment. It should be recalled that the interior of Asia was the ground in which Ellsworth Huntington[3] hammered out his particular theories of geographic determination of culture and culture history, dependence on rather than control of the environment. His explorations as a member of the Pumpelly expedition to Anau in 1903 suggested to him that progressive desiccation in the area during the historical period led directly to the downfall of cultures. This point of view still has to be combatted in 1961, as evidenced by an article in the current issue of the American Anthropologist by Raikes and Dyson[4] in regard to West Pakistan. Thus we must struggle not only with facts, but also with primitive thinking.

A simple-minded single-factor approach to human ecology has the advantages of elegance and neatness, but does violence to the data.

Another simplification has concerned the origin and nature of nomadism. Recent Japanese studies of Mongol nomadism have proposed that the cyclical movement of herds of domesticated animals is likewise a case of cultural adaptation to the environment. Behind this interpretation is an apt observation: the wild ungulates of the region--sheep, goats, equidae (including kulan or wild ass, onager, przhevalskii and camels--are cyclical in their movement over an annual period. But the inference drawn from this is a reduction or simplification of the truth. The range of movement of the equidae in the wild state is far greater than that of the sheep or goat. Causing all the elements of the herd, including kids, lambs, calves, and foals, as well as full-grown stock to move together, is a complex adaptation of a part of the environment, in this case the herds themselves, to the common, culturally imposed and adjusted pattern. Within this pattern there is some variation, by cultural conditions and by natural conditions.

Cultural Conditions of Variation in the Basic Pastoral Pattern of Nomads

Domesticated asses are herded primarily in western Asia, from the Zeravshan in western Uzbekestan across southwest Asia. This distribution must be ascribed to cultural factors; wild equidae: kulan or dziggetai (E. hemionus) and onager (E. hemippus), both closely related to the domestic ass (E. asinus) have been available for domestication by Asian cultures at various times during the past 5,000 years; they were husbanded

by sedentary farmers of ancient Shumer. The faunal environment is subject to control by nomads only up to a point: the yak and the yak-cattle khainyk, an interbreed, are raised only in high altitudes east of the Altay--T'ien-Shan-Pamir lines; they have not been adapted to low altitude conditions, despite the regard in which their milk and butter are held.

Variation through Natural Conditions

Simukov observed 30 years ago that cattle have best adapted to forest steppe, and less well to arid or mountainous terrain. Horses and sheep have adapted best to steppe and semidesert; goats to mountain or broken terrain; camels to conditions of maximum aridity. The various advantageous ecological positions of wild ungulates are minimized, within limits and not entirely overcome, under conditions of domestication by pastoral nomads.

Two primary variants of nomadism are conditioned specifically by terrain factors.

Kirgiz, eastern Kazakhs, and certain Khalkha Mongols nomadize in mountain pastures. Their ecological pattern is variant from that of the great mass of pastoral nomads who nomadize in the flat, whether plateau or lowland: Kalmuks, most Mongols of Outer Mongolia, central and western Kazakhs, Turkmens. Mountain ecology comprises great variation in small compass, and the track from winter camp to summer pasture is usually a short one for Kirgiz. This is usually accomplished in a month; they have no role for spring and fall pastures.

Nomadic pastoralism in flat country on the contrary usually comprises spring and fall pastures. However, in the case of Kazakhs of the Chu river valley, the summer pasture was in the Sary-Su, and the track lay across the Bet-Pak-Dala. The Hungry Steppe is not steppe, but desert, and can be traversed in the spring, during the period of brief desert florescence, and allows no time for pasturing. The return to the winter camp along the Chu is accomplished during the early fall, during the second of the double rainfall peaks in the year. Thus herding and feeding arrangements of the nomads are a partial picture of a complex culture: the Japanese approach is a simplification of these complexities.

Human contributions have been the development of mutual adjustments among all the stock, and mutual adjustment of herdsmen and herds. Herdsmen have made little adaptation of the flora: perhaps storage of winter fodder falls in this category. Maximum adaptation has been made of the herds, within limits, above all given lack of selective breeding.

The pastoralist in adapting the environment in this way has entered into symbiotic, that is, mutually supportive, relations with the herds. For

the pastoralist, the herds provide food as milk and milk products: cheese, including curds, butter, fermented milk, and distilled milk spirit. On ceremonial occasions a sheep will be slaughtered; however, this is akin to eating into one's capital: it is not an everyday affair. Wool, hides, and whole skins provide clothing, shelter and transportation trappings. Wool is beaten into felt, woven into cloth and carpeting, and braided into rope. Wool like milk, is a replenishable resource.

For his part, the herdsman constructs windbreaks against snowfall and snowdrift, behind which herds may find winter forage; he stores grass dried for fodder; he drives out diseased beasts in elementary quarantine practice against the outbreak of epizootics; he drives off and hunts predators: wolves, snow-leopards. He organizes and manages range, track and pastures, controlling competition between herds.

The mutual relations of dependence are a mode of conjunctive symbiosis of herd and human society.

But man is a wolf to the herd: human calamities--wars, revolutions, raids, deplete herds more quickly than wolves or winter storms.

Herds and herdsmen are dependent on the flora and the water and the pastoral nomads do nothing to replace their supply, but leave this to natural processes. Herds are not selectively bred; they are interbred with wild and feral stock: camels, asses, horses, yaks. The horses are a shortlegged stock of great endurance and wind, intermittently crossed with the equus Przhevalskii down into the 20th century. Wild and feral forms of these breeds are collectively called tarpans.

At eastern, western and northern periphery of their world of steppe and semidesert, they have entered into competition with farmers for resources. The lush steppe of southern Russia, fought over by Kievan Russians and Patznaks, the forest steppe of southern Siberia, and the steppe along the Great Wall of China, have been areas of competition for over two millenia, down to the 20th century. This competition has been only one form, and a minor one at that, of the relations of sedantary farmer and nomad herdsman.

Contact of herdsmen with farmers in these marginal zones has proceeded without interruption during the entire three millenia. Relations have taken the form of economic exchange, for which there exists no adequate analysis in occidental terms. We need a new theory of these economic relations: exchange under non-market conditions. Traditional economic relations of Tartars with Chinese cannot be analyzed in terms of market, commodity, circulation of commodities, trade, although these concepts predominate. They are ethnocentric notions derived from European

economics. Characterizations hitherto current of the socio-political system of Tartary, which has often been called feudal are likewise an ethnocentric error.

As to farming throughout the arid zone, it has been based on water control: by storage, conduit and deflection. Irrigation systems based on these principles are one-, two- and three-dimensional. The tilth is rich under conditions of water control, but limited in area. Not very much of it can be spared for stock-raising.

This proposition must be considered in the light of the population densities of farmers and pastoralists. Farming is relatively intensive exploitation of the soil. Population densities of Asian farming communities achieve rates 100-fold higher than those of herding populations. The range of population densities of herding populations of traditional type are from three persons in 10 km sq to three per km sq. Translated into economic terms, land is precious to the farmer; it is regarded by him as "wasted" if it is let for grazing.

Interdependence with nomadic pastoralists was and is necessary for farmers, therefore, but the traditional relations were clumsy and non-rational by occidental economic standards. The exchange system was instable, frequently broke down: it was a defective institutional net.

Many Middle Eastern farming cultures solved this problem by maintaining specialists in animal husbandry within the community, just as in the European tradition. Inland Asian practices evolved to the point of specialization in pastoralism by entire peoples, articulated as cultures.

Chinese and Tartars are joined in an institutional web with political and economic facies. Mongols and Tibetans are joined in a religious network, Lamaist Buddhism. Mongols and Turks are joined in a socio-political structure based on a common form of social organization, combined into pyramidal political hierarchies interlocked at key points of juncture.

Within these institutional frames, relations have broken down at times in the form of alternation of forms of amicable and belligerent relations have arisen.

A widely spread web of institutional relations, over and above these economic and politico-military relations was developed, which went far beyond the trans-marginal relations of Mongols with China, Kazan' Tatars with Moscow, Turkmens with Iranians. These institutional webs include the religious: the Buddhist monastic system emanating from India across Tibet and Mongolia to Siberia; the economic: caravan routes which brought Chinese silks across the width of Asia to Cairo, Byzantium, and Rome. Knowledge of early Turco-Mongol history is in part dependent on Chinese and Byzantine sources.

separates. [illegible] organizations [illegible] current [illegible] of Tibet, many [illegible] error.

As nothing [illegible] it has [illegible] controlled by [illegible]. Irrigation [illegible] their [illegible]. [illegible] conditions [illegible] it can be [illegible] for stock raising.

The [illegible] must be considered [illegible] of the [illegible] densities [illegible]. Farming [illegible] exploitation [illegible]. Population densities of [illegible] requirements [illegible] lower than those of farming populations. The range of population densities of herding populations [illegible] from [illegible] persons to 10 [illegible] per square mile. [illegible] it is regarded [illegible] for [illegible].

[illegible] therefore, but the traditional relations were [illegible] by [illegible]. The [illegible] inevitable, [illegible].

[illegible] tending [illegible] maintaining [illegible] within the [illegible], just as in the European tradition. [illegible] ization in [illegible].

China [illegible] and economic [illegible]. Mongols and Tibetans [illegible] Uighurs and Turks [illegible] situations [illegible] social organization, [illegible] interlocked [illegible].

With [illegible] relations [illegible] in the form of [illegible] or [illegible] political relations have arisen.

A [illegible] of [illegible] economic and political [illegible] beyond the [illegible] with China, [illegible] with Mongols, [illegible] the religious [illegible] the Buddhist monastic system [illegible] Tibet and Mongolia [illegible] China [illegible] knowledge of [illegible] Chinese and [illegible] sources.

A controversy has arisen concerning the independence of the pastoral nomad society and culture. I should like to elucidate certain cultural features of the Tartars in the exposition of this controversy.

Through the consideration of the institutional relations Alfred Kroeber concluded that pastoral nomads of Tartary are a half-culture, or a part-culture, such as the castes of India, Gypsies, or Jews of eastern Europe before Hitler. This view is possible: the definition of the constitution of an independent culture is quite variable. Moreover, if we choose a particular point in time: the 20th century, when pastoral nomadism has contracted to small areas; or the 13th century, when it dominated most of Eurasia, further credence is lent to the idea.

But most of the Tartar nomads, over most of their history, formed an independent set of peoples and cultures, with complex political, economic, military, religious, relations to their sedentary neighbors.

Nomadic Pastoral Cultures of World

Let us survey the distribution of nomadic pastoral cultures in the world. The Americas, and Oceania may be eliminated. Pastoral nomads have lived, or live today, in southwest Asia, North Africa and adjacent parts of sub-Saharan Africa: the Sudan and Nigeria, and in Inland Asia. A thousand years ago the south Russian steppe was part of the distribution. Thus, at their peak they extended beyond their locus classicus. The distribution until the recent past has been approximately co-terminous with the arid belt which stretches across North Africa from the Atlantic to southwest Asia and joins the arid system of Inland Asia.

Within this great zone, the pattern of nomadic pastoralism is subject to variations. In southwest Asia and north Africa, nomads live in angular tents covered with black cloth. The nomads of Tartary live in felt tents, vari-colored, in form a rounded cone set on circular lattice-frame. Clothing differs: burnoose in Arabia, and tailored clothing in the north. The Arab herdsman has the camel for his economic support, the horse for prestige and for war. To Arabs, the goat signifies the end of nomadism; it is raised only by sedentary villagers. The camel is the one-humped dromedary. In Iran, the Kashkai have complex herds, much as in Turkmenia to the north, but live in the black tent of southwest Asia. Here, and in Turkmenia and Uzbekistan, herds are composed of sheep, goats, asses, cattle, mules. camels, horses, in order of numerical size within the herds. Kazakh, Kirgiz, and Mongol herdsmen raise no asses, nor, therefore, mules; horses are of proportionally greater importance in consequence. Their camels are two-humped Bactrians.

The Mongols of Outer Mongolia have a vast domain of their own: Outer Mongolia covers 1-1/2 million km sq. Here herding and farming are mutually exclusive enterprises; less than 200,000 hectares, or

500,000 acres in this country are devoted to cultivation, a nonsignificant percentage of the whole. The easternmost part of the nomadic belt is a vast and specialized area of pastoralism. The great, monopolistic regime of livestock has long been in defective interaction, with a greater monopolistic regime of agriculture of China. The interaction has traditionally taken the form of exchange of pastoral for farming products, an exchange which is not to be confused with trade. The exchange must be considered defective because of the frequency of breakdown in the form of raids, wars, conquest dynasties. Interaction between Mongols and Chinese has been as between countries, or sub-continents.

To the west, in Sinkiang and Kazakhstan, the nomadic herdsmen and sedentary farmers have interacted on a scale at or below the province level, in contrast to the Mongol-Chinese scale. Individual cities of Kashgaria: Kashgar, Yarkand, Tashkurgan (Stone-mound) developed relationships with small-scale nomadic communities, clans and villages, rather than entire peoples. In 1929, Gunnar Jarring, the present Swedish ambassador to the United States, and a great Turkologist, or conversely, as he would put it, followed a caravan of Kirgiz nomads across the T' ien-Shans to Kashgar. It is only since that day that the border has been closed and the nomads of Kirgizia settled.

Kazakhs traditionally dealt with Tashkent, Vernyy (now Alma-Ata), Ufa, Orenburg. Kalmuks of the Volga dealt with Astrakhan, a great city famed for its fairs throughout the Russian empire. Their horses also commanded good renown in Poland and prices in modern capitalistic practice. Turkmens dealt with Mashhad, Mazanderan, Serakhs, Gorgan, Bender-Shah, other cities of north Persia, when they were not at war with the Persians. Again each Kazakh and Turkmen group dealt with particular cities.

The process was further narrowed in scope in southwestern Asia: Badawin and Tay Arabs customarily deal with smaller social units of sedentary farmers, villages and towns. The interspersal of nomadic and sedentary groups in the Middle East is like a mosaic pattern; farther north and east it is a design of larger and larger pattern.

Over geographic space and over historical time, the cross cultural relations of herding nomads and their sedentary farming neighbors are subject to considerable variation and elaboration. It is a matter of careful appraisal to adjudge the point at which an independent cultural unit is articulated on this scale. The Tay Arab herdsmen of northern Iraq are not, in our estimation, an independent culture, but are closely interrelated with their sedentary farming neighbors, many of whom are of Tay derivation themselves. The Kashkai constitute an independent culture in Iran. This conclusion is fortified if it is regarded through eyes sharpened by the study of Mongolia. In the eastern part of Tartary, the pastoral nomads constitute

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

an independent culture, if usual criteria of cultural definition be applied: articulated social organization, including religious expression, political independence, symbolic expression of cultural unity, degree of interaction with neighboring groups.

Beyond the theoretical evaluation of the question of part or whole cultures, there are practical considerations in the development of government policy toward the Mongolian People's Republic, which was reopened in recent months in the Department of State; in development of policy of the United States Information Agency and its radio, the Voice of America, toward minority nations in the Soviet Union and Mainland China.

Conclusions

We have considered, however briefly, the principal characteristics of the natural environment of Inland Asia and, in its broad categories, the ecological system of the nomad Tartars in relation to their environment, natural and social. The Tartars are culturally advanced, but only moderately so; they are advanced relative to the hunting peoples and reindeer breeders north of the steppe, in Siberia. They have not achieved the degree of complex division of labor and of complex, stable, political organization of the high cultures to the south, China and India. Their ecological system is correlatively developed: certain ecological relations, for example, their noninterventive dependence on natural supply of grass and water, are characteristic of primitive cultures; on the other hand, the symbiotic relations with the herds are evidence of a degree of control, that is intervention by human device, characteristic in other directions of technically advanced, complex cultures.

The close relations which have been established between the pastoral nomads and their environment are important for the contribution their study makes to ecological theory. Their relationships of adaptation to the environment and adaptation of the environment are delimited geographically. Conditions are thus established for formulation and verification of a number of hypotheses concerning culture and environment: notably, conditions under which unrelated cultural modes may compete for occupancy of habitat marginal to both; for example, competition for the south Russian steppe and for control of the grassland immediately north of the Great Wall of China. The culture of Turco-Mongol pastoral nomadism is well defined by its characteristic features in space and time. We may, therefore, study the conditions of its formation and development. Its course is now all but run; we may study the conditions of contraction to a few isolated enclaves.

Because of the sharp definition of the culture in its beginnings, its distribution and its present state, a significant contribution can be made to the study of evolutionary processes, with particular reference to ecological

an independent nation), if genuine fusion of cultures is to be [illegible]. [illegible] social organization, [illegible] political independence, symbolic and emotional national feelings, [illegible] interaction with neighboring nations.

Beyond the [illegible] of the questions [illegible] minorities, there are [illegible] development of government policy toward the [illegible] which was [illegible] in recent months in the [illegible], in development of [illegible] of the United States [illegible] radio, the Voice of America, toward minority nations in the Soviet Union and Mainland China.

Conclusion

We have considered, [illegible] of the natural environment of Inner Mongolia, [illegible] the ecological system of [illegible] in relation to their environment, natural and social. The [illegible] are culturally [illegible] so, they are advantaged [illegible] to the [illegible] peoples [illegible] north of the [illegible]. They have not [illegible] of complex, stable, political [illegible] of the high [illegible] to the [illegible] China [illegible]. Their ecological system is comparatively developed [illegible], for example, [illegible] intervention [illegible] characteristic of [illegible] on the other hand, [illegible] relations with the [illegible] and [illegible] by [illegible] advantaged [illegible] cultures.

The [illegible] nomads and [illegible] study [illegible] the environment [illegible]. Conditions [illegible] of hypothetical [illegible] under which unrelated [illegible] may compete for [illegible] original to each; for example, [illegible] of the [illegible] of the [illegible] of China. [illegible] of [illegible] in space and time. [illegible] the [illegible] of [illegible] of [illegible] or a [illegible].

Because of the [illegible] definition of [illegible] its beginnings, its differentiation and its present state, [illegible] the study of [illegible] with [illegible]

conditions under which a culture is formed. This point bears emphasis: the conditions, not causes, of cultural formation. The accumulation and flow of scientific information has accelerated during recent decades in such a degree that it is conceivable at the present time to investigate the evolution of particular cultural types; the scope of such an investigation is conformable to those of the physical geographer who is studying the evolution of particular landscapes, even though the time scales involved may be different. There is even an overlap in techniques in the two types of investigation. Hopefully, a comparable state of maturity of the two disciplines may be attained.

The study of the Tartar culture requires the combined study of historical texts, covering some 2,500 to 3,000 years, together with the archaeological and the ethnographic records of these peoples over the same period. Through this combined study it is possible to study the evolution of the culture, for soon after it was formed, their sedentary, literate neighbors began to write about them. We differentiate this kind of study from the study of cultural evolution in general. But we may return to the more general question when the study of this and a number of other particular evolutions have been completed.

Notes

1. P. Pelliot, Horde d'Or: 232-3; W. Rockhill, Rubruck: XVII; Yule-Cordier, Polo: passim.

2. J. Steward, "Basin-Plateau Aboriginal Socio-Political Groups," BAE Bulletin 120.

3. E. Huntington, The Pulse of Asia, 1907.

4. R. L. Raikes and R. H. Dyson, "The prehistoric climate of Baluchistan ..." AA 63.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 32. The Nature, Mechanisms and Consequences of Changes in Human Populations (Shimkin)

I. General

Scientific understanding of the history, causes and consequences of the growth, fluctuations, and structural changes of human populations is still rudimentary. Yesterday's gross errors show that today's facts and forecasts are subject to future correction. Note that expert opinion in 1937 (Carr-Saunders) anticipated an early ageing and decline in size of the European and U. S. populations. Again, Kroeber's 1939 estimate of the pre-Columbian population of Mexico was less than a fifth that calculated by Cook and Simpson in 1948. No one anticipated either the enormous decline in fertility in the then-colonial regions or the dramatic rises of the U. S. and Canadian, and drops of the Spanish, Italian and Japanese, birth rates. Nor was the wide extent of population control among primitive and peasant peoples appreciated. Thus, the demographic literature of the 1920's and 1930's was rather self-assured, to the point of toying with "laws" of demographic development. At present, human population dynamics appear to be highly malleable interactions of demographic potentials, perceived values and anticipations, and levels of social organization and conflict, within broad bounds set by disease and the limits of food supplies.

The major demographic facts which appear tenable are the following:

1. The world's population, as a general trend, has had an accelerating growth, reaching a few million at most prior to the advent of fishing and seed extraction, about 10,000-12,000 years ago. By 2,000 years ago, it appears (largely from data on China and the Roman Empire) to have approximated 150-200 million. By 1650, according to Carr-Saunders' estimate, it exceeded a half billion. In 1800, it was about a billion persons, and in 1900 it probably exceeded 1.5 billion. The current figure is between 2.5 and three billion persons, with much uncertainty in the data for China, southeast Asia and Africa.

2. This general trend unquestionably includes important world-wide fluctuations, the period 1200-1350 A.D. probably being one of actual population decline from military destruction, unfavorable weather and the plague. Moreover, population histories in older and newer centers of permanent field agriculture and urbanism have been rather different. Overall, maximum population densities in old, well-favored centers have grown

far more slowly than have the areas of medium-to-high density.

3. For at least three hundred years, and perhaps for two thousand years or more, the Far East, Southeast Asia and India together have held at least half the world's population. The Near East, North Africa and Europe have had about another quarter, but the population axis of this area has shifted, over the last 200 years, from the Mediterranean to the North European plain. In the rest of the world, the major historic trends have been the explosive peopling of the Americas and the slow growth, thanks largely to the slave trade, of sub-Saharan Africa.

4. In young, healthy human populations with institutions favorable to high fertility, birth rates of 50-55/1000 can be maintained for long periods, e.g., in Quebec between 1670 and 1790. Heavy maternal mortality, as among nineteenth-century Russian peasants, can reduce birth rates by a fifth or more. Heavy infection with venereal diseases or malaria, coupled with dietary deficiencies, may lower live birth rates even more. Cook's figure (1943, III, p. 18) of 23/1000 for northern California Indians in 1885-1890 represents essentially unregulated fertility under very adverse circumstances. Under more normal circumstances, crude birth rates much under 40/1000 may be considered as greater or lesser consequences of social or physical restraints, including selective out-migration, upon fertility.

5. Fertility controls are both old and widespread in human societies; they have been imposed by primitive, peasant and urban peoples when the birth of children would threaten major goals, particularly those of virtuous reputations among the unmarried, and personal and child welfare among the married. Characteristic consequences are attempts to avoid all births, or to space births, or to limit surviving births to some maximum number. Fertility control, especially abortion and infanticide, to mitigate extreme distress, ward off starvation or consciously hold down numbers seems rarer. Hunting and gathering peoples such as the Northern Athabascan Indians (Shimkin, 1955) are prone to such practices. Fertility control is generally cloaked with secrecy; it diffuses poorly. Inefficacious, sometimes purely magical, methods tend to persist. Some spread took place from India via the Near East to Europe in Classical and Medieval times; since the end of the eighteenth century a more general wave has spread outward from France and England, and from urban to rural groups. However, fertility control seems also to have gained pace independently in other areas, such as Eastern Europe after 1850, and often been most intensely practiced in rural, conservative peasant environments under conditions of severe land pressure.

Fertility control in man is achieved largely by five means: social means reducing marriage rates and sexual activity in marriage; sexual anomalies, particularly interrupted intercourse; chemical and physical contraception; abortion; and infanticide. Apart from a few transcendentalist cults in Russia, human sterilization (castration or other means) has not been a significant aspect of fertility control.

a. Large celibate populations, which include as much as half of the adults, are found in several areas, especially pre-Communist Tibet and Mongolia and present-day Finland and Ireland. Less extreme conditions are found in other regions, such as primitive Melanesia. Common elements in these patterns are economic preconditioning such as land ownership, for marriage, and institutional facilities, such as monasteries, nunneries, men's houses, pubs, widespread alcoholism and prostitution permitting benevolent or dissipated alternatives to marriage. Polygamous societies, such as those of Black Africa and the Moslem World, may or may not be characterized by socially reduced fertility. Where marriages are stable, with bride purchase, and where sexual intercourse is prohibited during nursing, spacing ensues. This, accompanied by high infant mortality, reduces live births.

b. Sexual anomalies to reduce the probability of conception appear to have been rather widespread, both in primitive societies (e.g. Black Africa) and in the modern west. However, sexual deviancies appear to stem almost totally from other causes, especially the rejection of normal social roles and the scarcity of normal partners.

c. Chemical and physical contraception of effective types appears to have been known in India, the Mediterranean and parts of Eastern Europe from ancient times, but been available only to small groups of the upper classes and prostitutes. In modern times, it had two foci of development: France and England. In France and adjoining areas, i.e. Geneva, contraception was being practiced by the late seventeenth century among the burgesses. Its effects were to reduce completed family sizes and to advance the end of reproduction, among wives, from the 39th year to the 34th year and later to the 32nd, on the average. Advanced ages of marriage and lifelong celebacy among men were concurrent trends. In French rural areas, birth control began to be effective after 1780, and was widespread from the first. Here also the main effects were completed-family limitation and wider spacing between births. In all these cases, maternal life expectancies and infant survivals improved concurrently; thus birth control in France was in considerable part a segment of a larger improvement in hygiene.

In Britain, contraception was practiced by seventeenth century roisterers, such as the auto-biographer Boswell, but birth control developed as a conscious social movement after Malthus. The earliest propagandist, Francis Place, endeavored to educate the female textile workers against the strains of excessive and illegitimate births and abortions in the 1820's. Birth control grew as part of the general feminist movement, but received no decisive impetus until the sensational Bradlough-Besant trial of 1877-79. In the United States, the Utopian Socialist Robert Owen was an early propagandist of birth control among industrial workers but here again little was realized until the 1880's. Over-all, while the social context of continental birth control was propertied, in both Britain and the U.S. it was deeply associated with social protest.

II. Reference Data.

1. <u>Required Reading.</u>

Thompson, W. S.: <u>Population and Progress in the Far East</u> (Univ. Chicago Press, 1959), pp. 11-32, 380-403.

2. <u>General References.</u>

a. Basic reference data, items no. 9 (Kroeber), 11 (Thompson), 12 (Kiser and Boudreau), and 13 (Freedman, Whelpton, and Campbell).

b. Specialized demographic materials:

Adams, Robert M.: "Agriculture and urban life in early Southwestern Iran," <u>Science</u> 136: 109-122. 1963.

A careful but qualitative assessment of the intensification and urbanization of settlement in Near Eastern flood plains from 5000 B.C. up to the Sassanian period (500-700 A.D.). A review of factors inducing subsequent decline.

Angel, J. Lawrence: "Social biology of Greek culture growth," <u>American Anthropologist</u> 48: 493-533, 1946.

An extremely interesting attempt at correlating demographic and cultural phenomena in Greece between 3000 B.C. and 1000 A.D. The medical aspects are well sketched, <u>i.e.</u> growth in skeletal size with prosperity. The importance of racial admixture as a phenomenon in the development of the Greek population is stressed.

Baumhoff, Martin A.: <u>Ecological Determinants of Aboriginal California Populations</u> (University of California Publications in American Archaeology and Ethnology) 49: 155-236, 1963.

A fundamental analysis of the food resources and population of a pre-agricultural population. The new estimates for California's aboriginal total (ca. 350,000) triple Kroeber's and suggest that... "an agricultural economy would have been less productive than the native economy [acorn-gathering, fish, large mammals] in the initial stages.... The state of Malthusian equilibrium [which he ascribes to aboriginal California] means that there was no slack, so that any diversion of manpower... to... agriculture would result in a net loss of production.... Looked at in these terms it is clear that possible environmental

d. Abortion, although deeply repulsive to Christian ethics, has been a widely practised means of birth control, in the primitive world, among the classic civilizations and in recent times. Currently, it is believed that fully 1/2 of all conceptions in Japan, Hungary and several other countries are aborted. Birth control through abortion is legal on numerous grounds in these countries and others such as the USSR, but all attempt to dissuade women from having recourse to this brutal and dangerous technique. The justifications for legalized abortion presented by practicing states are attempts to avoid even worse consequences in death and mutilation from widespread illegal terminations.

e. Infanticide, commonly practiced through exposure, is usually selective. Where used to limit populations, it is largely female, and has as its consequences disbalanced adult sex ratios and, often polyandry. In areas where feminine virtue is prized, infanticide as well as abortion are common among the unmarried.

6. Mortality in man is largely caused by disease, often abetted by malnutrition, exposure and fatigue. In general, mortality rates in agricultural societies prior to 1750 appear largely to have been density-dependent. Thus, migration to the New World, which permitted a long period of low-density settlement, was a major factor in the tremendous natural growth of the American population. Conversely, the gradual, sometimes cyclical decline of long-settled areas, such as Egypt, Mesopotamia, coastal Peru (Viru valley) and even the Mississippi (Cahokia), may in appreciable part be due to the steady climb of diseases. Enteric infections and tuberculosis are particularly suspect as causes, world-wide. Malaria, an Old-World scourge, played an important part in the depopulation of the Americas after 1492.

Diseases have two types of effect, selective and general. The first is most important in its genetic and demographic effects; the second, characteristic of unselective killers such as plague, typhus, cholera, yellow fever and smallpox, leaves population little changed, except in numbers. Since the rise of vaccination, hygiene and antibiotics, early mortality has become increasingly selective. In general, since genetic susceptibilities are the major discriminating factors in survival now, the net effect, given lower fertility, is to reduce their frequency in the population. The preservation of the handicapped, who have generally much lower fertility (if any) than the remainder of the population has minor offsetting force.

7. The final element of demographic significance is migration. This is important directly because it is generally selective, and hence changes the structures of both receiving and donor populations, and because it results in changes in patterns, as well as numbers. Since the development of agriculture, the greatest effect of migration, far exceeding international movements in scope and persistence, has been the phenomenon of reconcentration termed urbanization.

bariers [to maize-type agriculture] are irrelevant." (pp. 227-28).

Bergues, Helene et al: La Prevention des Naissances dans la Famille. Ses Origines dans les Temps Modernes. (The Prevention of Births within the Family. Its Origins in Modern Times.) Institut National d'etudes demographiques. Travaux et Documents. Cahier No. 35. Paris: Presses universitaires de France, 1960.

A basic synthesis of research on the history of birth control, especially in France and England.

Borah, Woodrow: New Spain's Century of Depression. Ibero-Americana: 35, 1951.

An incisive summary of the social mechanisms which promoted a collapse of Mexican populations between 1550 and 1650.

Carr-Saunders, A.M.: World Population, Past Growth and Present Trends. London: Oxford University Press, 1937.

An analysis of permanent importance. Its projections of stabilization and even early decline in European and American populations failed, as did all others, to anticipate the declines in mortality and the rises in fertility of succeeding decades. Its discussions of international migrations, and of the population problems of non-European countries on the eve of World War II are also valuable.

Coale, Ansley J. et al: Demographic and Economic Change in Developed Countries. National Bureau of Economic Research. Special Conference Series No. 11, Princeton, N.J.: Princeton University Press, 1960.

A meticulous analysis of detailed trends and correlates with marriage and fertility in selected Western European countries and the U. S. since World War II.

Cook, Sherburne F.: "The extent and significance of disease among the Indians of Baja California, 1697-1773" Ibero-Americana 12: 1-40, 1937.

This basic analysis estimated that, in Lower California, the population declined from 41,500 in 1697 to 5,400 in 1777.

Excessive mortality in the missions, largely from introduced diseases, plus the loss of women /slavery and concubinage to whites? - DBS/ were responsible factors. The population decline shown appears to have been characteristic for Spanish America. Comparable results are shown in S. F. Cook: "Population trends among California Mission Indians." Ibero-Americana 17: 1-48, 1940.

Cook, Sherburne F.: The Conflict Between the California Indian and White Civilization. Pt. I. The Indian versus the Spanish Mission. Ibero-Americana, 21, 1943; Pt. II. The Physical and Demographic Reaction of the Nonmission Indians in Colonial and Provincial California. Ibid., 22, 1943; Pt. III. The American Invasion, 1848-1870. Ibid., 23, 1943; Pt. IV. Trends in Marriage and Divorce since 1850. Ibid., 24, 1943.

The most thorough study made to date of the effects of social destruction upon the demography of a non-agricultural population.

Cook, Sherburne F.: Soil Erosion and Population in Central Mexico. Ibero-Americana 34; 1949.

A careful study of the history of land deterioration which concludes that... "Spanish agriculture, deforestation, and livestock grazing merely finished what the red man had already nearly carried to completion" (p. 86). Also, that this indication of Malthusian pressures requires long time allowances... "we must concede the passage of 3,000 to 5,000 years since the first establishment of the corn-cultivating, pottery-making cultures on the plateau." (ibid.)

Cook, Sherburne F. and Lesley B. Simpson: The Population of Central Mexico in the Sixteenth Century. Ibero-Americana: 31, 1948.

A detailed analysis of Spanish population records on Mexico which led to the radical conclusions that this area held 11 million people in 1519 (p. 33), and that this population plummeted to 2 million by 1600 (p. 46). This estimate is 5-1/2 times as high as Kroeber's and 80 per cent as high as the population of the same area in 1930. Corroborating the statistical evidence of decline are the results of two other studies by Cook (1949) and Borah (1951).

Ganiage, Jean: Trois Villages d'Ile-de-France au XVIIIe Siecle. (Three Villages of the Ile de France in the Eighteenth Century). Institut national d'etudes demographiques. Travaux et Documents. Cahier No. 40. Paris: Presses Universitaires de France, 1963.

Detailed demographic histories, in well-defined socio-economic contexts, of three rural communities in central France. The control of fecundity within marriages performed after 1780 is demonstrated (esp. pp. 113-4).

Nadal, J. and E. Giralt: La Population Catalane de 1553 a 1717 (The Population of Catalonia [Spain] from 1553 to 1717). L'immigration française et les autres facteurs de son developpement. (France immigration and other factors in its development). L'Ecole pratique des hautes etudes. Centre de recherches historiques. Paris: S.E.V.P.E.N., 1960.

A meticulous study of the demographic history of eastern Spain. It utilizes registrations from 1359 to 1553 as a base, and the census of 1717 as a terminus. For the 164 years of basic analysis, parish records and detailed materials on immigration have been reviewed. The treatment of epidemic diseases is especially valuable; it shows losses of 25 to 50 per cent of the population in single bad plague years (1530, 1647) (pp.25-45). The data on the ages and occupations of the French immigrants are also extraordinarily precise (pp. 129-153).

Pritchard, Earl H.: "Thoughts on the Historical Development of the Population of China," Journal of Asian Studies XXIII, 3-20, 1963.

A thorough review of recent work on the world's longest population series. Current data indicate for Han China (i.e. exclusive of most areas south of the Yangtze) a population of some 60 million in 2 A.D. A comparable figure for 750 A.D. is 75 million; for 1200 A.D., 110 million; for 1600 A.D., 150 million; for 1790 A.D., 310 million; for 1850 A.D., 430 million; and for 1953, 518 million (in somewhat larger boundaries).

Rosenblat, Angel: La poblacion indigena y el mestizaje en America (2d. ed.) (The Indigenous Population and Race Mixture in America). Vol. I: La poblacion Indigena, 1492-1950 (The Indigenous Population, 1492-1950); Vol. II: El mestizaje y las castas coloniales (Race Mixture and Colonial Castes) Buenos Aires: Editorial Nova, 1954.

The fundamental compilation of primary Latin-American records on the population history of the Americas by a competent historian. A starting place for all future work; needs amplification on the procedural aspects of Spanish censuses and enumerations.

Taueber, Irene B.: The Population of Japan. Princeton University Press, 1958.

Perhaps the finest study of the history and social conditioning of a population made in recent years. Emphasizes the long tradition and effective re-imposition, post World War II of birth control through abortion in Japan.

United Nations: Demographic Yearbook 1961 (New York)

The fundamental source on world demography. Brings out the basic measures and the high variability in coverage and reliability characteristic of data on various nations.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 33. The Nature of Cities and the Rise of Urbanism (Fellmann)

The city is an artificial construct, not a natural ecological unit. It is the creation of man designed to perform tasks which, at the time of its development, could not with equal success and efficiency be performed in other environments. The city is not a self-contained unit; from its earliest beginnings, the true urban unit has been characterized by the performance of a function or functions for an area and an economy larger than, and outside of, itself. The city is, then, traditionally and contemporaneously a functional unit. It is, simultaneously, a social unit, for its functions are performed by people living and working in agglomeration.

This functional and social unit is characterized by: specialization of labor, a formally structured society, and specialization and a hierarchical structure in land uses. There are, of course, contrasts between the pre-industrial and industrial city; none the less, the described traits have been enduring.

The problem of definition of the term "urban" is tricky. It is here assumed to refer to agglomerated settlements which are non-agricultural in function, and which are not exclusively dormitory in nature. With these assumptions as given, urbanism is seen to start late in the history of man; group dwellings of family or tribal units are not urban, nor were the hunting villages of the Paleolithic era or the agricultural villages of the Neolithic. We see, then, the seeds of urban tradition in the "city civilizations" of Egypt, Mesopotamia, and India.

Although reasons for the change from village to true urban life are conjectural, urbanism first developed between 5000 and 3500 B.C. in Mesopotamia and Egypt. Population pressures, migrations, and conflicts between hunters, herdsmen, and agriculturalists, appear to have spurred a more formal control of agricultural societies dependent upon fortified central places and the group-supervised control of large-scale farming enterprises requiring--for their success--land reclamation or other control of the forces of nature.

These needs and the cities to which they gave rise were found in great river valleys: The Hwang-Ho--Yangtze Kiang in China, the basins of the Indus and the Ganges in the Indian Subcontinent, the Assyrio-Babylonian

civilizations of the Tigris and Euphrates in the Near East, and Egypt and the Nile Valley of North Africa. The organization of agriculture which these complex societies undertook required, first, a true specialization of labor--farmer, laborer, soldier, metal worker (as bronze and iron ages dawn)--and required as well both a secular and ecclesiastical hierarchy for purposes of control: hierarchies far more pervasive than the simpler control forms of Neolithic villages.

Within this context the pre-industrial city displayed certain characteristic traits. Its existence was dependent upon the creation of an agricultural surplus; that surplus was required to support the ruling class or classes--secular and/or ecclesiastical. Attached to these dominating groups were specialist bureaucrats, administrators, supervisors, etc. Domination by superior classes was maintained through inheritance, "theocratic sanction," and military power. The agricultural peasantry presumably supported both the urban unit and particularly the power elite through payment of tribute; further support comes through complete control--by custom or ownership--of subordinate artisans and laborers.

The size of the urban unit is theoretically limited by its ability to secure the necessary surplus food items as well as by its ability to control subordinate agricultural populations. The city, to exist, is required to secure necessities from outside of itself. These necessities must be transported. The argument, therefore, runs: the size of the city is limited by the efficiency of transport media available to it and/or is limited by the productivity of its accessible hinterland.

In return for the commodities which it consumes, the pre-industrial city has limited alternatives: it has the option of taxing rural areas by such devices as offering protection, demanding religious tithes, or owning as personal property the body and the work of the rural workers. It can engage in various forms of trade activity. In the long run, city-rural economic relationships must exhibit reciprocity. Despite the "power hierarchy" which it displayed, the urban unit in preindustrial societies did not engage in battle for survival with rural areas; the concept of compatibility of interests was, in the long run, paramount.

City functions at the dawn of urbanism were dominated by trade, fortification and refuge, theological centrality, and manufacture.

The spread of the city owes as much or more to extension of local trade activities as it does to independent invention. The development of colony cities and outlying urban nuclei to supply domestically unavailable raw materials, for example, led to the spread of urban units from Sumer to the Indus Valley.

[illegible] of the Tigris and Euphrates in [illegible] and in the [illegible] North Africa. The [illegible] these complex [illegible] structures [illegible] required [illegible] both a [illegible] [illegible] Neolithic villages.

Within this context the [illegible] city developed its characteristic traits. [illegible] specialists [illegible] and military [illegible]. The [illegible] through [illegible] and [illegible].

The size of the urban [illegible] limited by the ability to [illegible] as well as [illegible]. The city [illegible] of food [illegible].

In [illegible] city [illegible] of [illegible] its [illegible].

City functions [illegible] Both [illegible] and [illegible] centrality [illegible].

The [illegible] of the city [illegible] trade [illegible]. The [illegible] of [illegible] urban [illegible] to the Indus Valley.

The mother cities--and particularly colony cities--early displayed a distinctive and structured land use pattern. Examples may be seen both in Ur, in the Near East, and at Mohenjo-Daro and Harrapa in the Indian Sub-continent. By 3000 B.C. functional specialization in land uses is seen.

The ordered Near Eastern city was not converted directly into a comparable urban unit within the Greek or Roman World. Greek cities apparently began with a dominating religious, rather than purely economic, function. However, by the fifth and fourth centuries B.C.--traditionally, though not actually, under the influence of Hippodamus of Miletus--more ordered and functionally advanced cities were developed. As in earlier cultures, the planned Greek city demonstrated the checkerboard street system and a hierarchical structuring of land uses. In the Greek culture, the establishment of new or colony cities was not purely a matter of economic or functional rationalization. Religion, prophecy, superstition, as well as practical considerations underlay ultimate decisions of city location and internal form. Developing local and inter-regional trade, functional sophistication, labor specialization, and social stratification soon resulted in urban communities embodying many modern characteristics. The advanced Greek city was characterized by a central agora with associated shrines, public buildings, and shops; the rectangular or gridiron street system, differentiated residential areas; paved streets; sewers; water supply; zoning ordinances, etc. Greek cities and their Roman successors expressed in nearly modern terms a full range of urban functions. Primarily based upon trade, they were individually or collectively transportation centers, governmental centers, market towns, religious and educational (collectively "institutional") towns, cultural centers, and certainly not least, industrial communities. The Greek tradition of urbanism was transferred to the Roman world. The same range of functions and the same urban complexity characterized the majority of Roman Empire towns. Only Rome itself--in its later years--must be excluded from the list of true "urban" centers developed in the Classical World. Rome--though displaying many of the contemporary responses to urban complexity and congestion--must be seen as a highly subsidized, non-economic city-type unit.

<u>Required Readings</u>

Gilmore, Harlan W. <u>Transportation and the Growth of Cities</u>. Chapters 1-3.

Gallion, Arthur B. <u>The Urban Pattern</u>, pp. 3-32.

Hilberseimer, L. <u>The Nature of Cities</u>, pp. 13-80.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 34. The Pre-industrial City: Western Europe (Fellmann)

While the fall of Rome did not spell an immediate or an inevitable decline of urbanism in Western Europe, that decline followed shortly after the closing of trade by Western European communities in the Mediterranean, consequent upon the spread of Islam and the refusal of Christian governments within the former Western Empire to deal with the Moslems.

By the middle of the 7th century, sea trade had declined both in Southern Europe as a consequence of Moslem advances and in Northern Europe as a consequence of Northmen depredations. While both Venice and certain Flemish cities remained important trade points, the majority of urban Europe underwent decline with the loss of long-distance exchange of common and bulk commodities.

The pattern of urban development during Western Europe's so-called "dark ages" followed the sequence: disintegration of trade, thus decline of urban life; virtual dissolution of cities, and, therefore, diminution of the market for farm products; decline of the farm market, therefore, a general retreat into subsistence agriculture (the "economy of consumption" as Pirenne has dubbed it). The decline in inter-regional trade and the concomitant decline of urban dominance is therefore associated with the rise of the cultural and social milieu known as "feudalism."

Within Carolingian Europe the few remaining centers with vestiges of urbanism had the following collective or individual characteristics: reduction in the range of functions developed in an earlier, freer economic society; featured ecclesiastical functions, so that in many instances the "urban" population was composed primarily of clerics, monks, students, and servants subservient upon the former; displayed a purely local market function; were walled and physically restricted within protective ramparts, with former "suburbs" demolished for protective reasons; and were to be influenced by the rise of fortified urban nuclei embodying the castle or fortress concept in formerly non-urban agricultural lands. Defence needs, in an age of destruction of centralized government, become paramount; the "burgus" develops as a new potential urban nucleus.

By the 11th century, a true commercial revival is found within Western Europe; the onset of the crusades brings new social vigor, and

labor surpluses helped change conditions characterizing earlier Carolingian Europe. Both Venice and the Flemish coast provide examples and origin points for the spread of an active urban economy.

Revival of trade--consequent upon the opening of the Mediterranean to Western European shipping, upon the conquest of England and the development of new markets for Flanders, and upon the forced retreat of the Northmen--transformed the urban economy of Western Europe. Subsequent economic development freed society, converted agriculture from subsistence to commercial production, and provided a growth basis for urban development. Both the long-standing "ecclesiastical town" and the more recently developed "burgus" served as nuclei for subsequent urban development. A developing merchant class composed both of immigrant Venetians and Flemish as well as of indigenous entrepreneurs subsequently--by their social and legal demands within a restrictive ecclesiastical society--transformed urban populations and altered the structure of feudal organizations.

The rise of the merchant class, and the expansion of the urban society attendant upon it, resulted in the development of a totally new (to feudal minds) social milieu. Involved was the rise of a middle class, the development of a nominally free but frequently economically depressed labor and artisan group, and the continuous erosion of the former prerogatives of both the lay and ecclesiastical hierarchy.

The internal structure of the medieval city was directly related to its originating nucleus. Those which developed within the context of a pre-existent ecclesiastical town tended initially to fill up the area within the existing fortifications; homes, monasteries, cathedrals, and warehouses, places of manufacture and places of business became intricately interrelated. Where the "burg" or "burgus" was the nucleus of the new urban unit, lack of space within the fortifications resulted in "urban sprawl" within newly developed suburbs or "Faubourgs" or "New Burgs"; these latter were by name and tradition distinctly contrasted to the "Old Burgs" inhabited by the "Castellani," who never became identified with the "Burgher," or merchant, population of the suburbs.

The "New Burgs" were largely unplanned; they were characterized by: (a) an irregular street pattern; (b) an irregularity of blocks; (c) an irregularity of orientation of structures; (d) old and eventually useless walls, replaced by circumferential roads.

The Medieval town was a complex of land uses, and all uses had to be housed within a space at least temporarily restricted by the protective walls of the community. The market place, the permanent dwellings for merchant and artisan, structures for the storage of goods, buildings to

house the intricate commercial activities of the developing community, quarters for the meetings of community organizations and the municipal authorities, provision for the housing of urban military establishments, area for the church or churches and the material appurtenances of the priesthood, cathedrals as seats of the bishops (in the larger towns), areas for monastic institutions, and sites for the developing guild halls all were provided--leading to a complicated physical structure.

After 1350--for a variety of reasons--the rate of new town formations and urban growth in Western Europe substantially declined. By 1500, the urbanization of Europe is essentially completed as far as the distribution and number of cities that the continent would contain for the next 300 years was concerned. Such stability should not imply stagnation. Rather, growth, development, and maturation characterized the urban scene during the three centuries prior to 1800. First, we can trace the rise of a mercantilistic economy in which the restrictiveness of Craft and Merchant Guilds was abandoned; and, toward the end of the period, we see the beginnings of the industrialized city--prototype of present urban centers. The decline of Feudalism and the rise of the centralized state are developments which had material urban impact.

With the rise of the central state came the decline in the independence of individual Medieval cities and a termination of the near equality in size and functions of existing urban centers. With centralism and with its concomitant mercantilist appendages, there develops that which is now commonly accepted: the large, complex, multi-functional metropolitan center.

Simultaneously, other urban patterns emerge: (1) the creation of an economically, rather than politically or socially, stratified society; (2) the development of higher urban densities and the emergence of the compact and congested city; (3) increased specialization of land use within urban units; (4) the development of specialized or "unifunctional" cities; (5) the creation of a philosophy or art of urban redevelopment and planning.

Associated with the Renaissance, an increase in wheeled traffic, and, above all, with military needs and imperial desires, the "Baroque" city is ushered in. "Squares", Processional Avenues, building-height controls, and circumferential avenues become part of the new city pattern. Simultaneously, there is increased stratification in urban residential and economic land uses and an increasing segregation of the upper and lower economic classes.

Required Reading

Mumford, Lewis. The Culture of Cities, pp. 13-222.
Pirenne, Henri. Medieval Cities (passim)
Dickinson, Robert E. "The Growth of the Historic City," in Mayer and Kohn, Readings in Urban Geography, pp. 69-83.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 35. The Industrial City and External Urban Relationships (Fellmann)

The Industrial Revolution ushered in a new phase of urban development within Western Europe. The first, and morphologically determining phase, was characterized by the railway, the steam engine, and early mass-transit systems. The urban results were: (a) an increase in urban congestion, consequent upon a limited range of power transmission, and an influx of urban workers; (b) an increased differentiation of land use within cities; (c) an increasing urbanization of Western Europe's population (for the first time the number of urban dwellers exceeded the number of rural citizens); (d) the development of new urban centers in growing industrial districts where raw materials--particularly fuels--were available; (e) the emergence of a new urban distribution pattern based upon the developing transportation (railroad) lines; (f) the introduction of a new urban land use--railroad facilities--within the developed community; and (g) the beginnings of a specialized, compact pattern of suburbanization.

While urban populations were increasing, so urban complexity was augmented. Limited possibilities in effecting separation of place of residence and place of employment implied increasing land use densities and a furthering of a hierarchical structuring of land-use. The development of mass transit systems, plus the restricted location of employment centers, gave rise to a differential structure of "rent-commanding" abilities of urban properties. For the first time, a truly stratified land-use pattern in the modern sense emerges. Speculative increases in urban property values contribute to an emerging pattern of rigidity within the land-use patterns of cities.

While internal structure--to which topic we shall return later--was becoming increasingly formalized and standardized, certain obvious patterns of urban size, spacing, and rural relationships were emerging.

In certain urban environments--of which the United States is a classic example--the "rank-size" relationship between cities is well expressed. This rule, expressed by the formula $S_r = S_{1/R}$ suggests that the size ranking of any given city within the totality of urban communities can be derived by dividing the population size of the largest city by the size of a given city. The "rank-size" rule expresses an observed mathematical pattern of urban sizes within the United States. It suggests, for example, that our largest of metropolitan areas--New York City--is approximately twice the size of our second

metropolitan area--Chicago; that the fifth largest area, Detroit, is approximately 1/5 of the size of the largest S.M.A., etc. It may be observed that the rank-size rule applies nearly equally well to the size structure of American cities at any census date since 1790, even though individual cities have changed their position vis-a-vis the total urban structure of the nation. Such a rank-size hierarchy--peculiar, although not unique in the United States--suggests a logarithmic straight-line relationship between the sizes of American cities.

Urban size, obviously, is related to urban population-supporting capacity. Such capacity depends upon the number and variety of functions housed within the individual community. Only through the performance of economic functions can an urban population exist. The observed size-hierarchy of cities, therefore, must correspond to an assumed functional hierarchy.

Urban functions may be very crudely grouped into two classes: "central place" functions and "special" functions. The associated performance of these two classes of functions give rise to the rank-size hierarchy already observed.

"Central place" functions are those that we normally associate with the "market town"--retailing and wholesaling of goods, collection of farm produce, provision of urban-centered professional and personal services, etc. Such "central place" functions are distributed among modern urban communities in a hierarchical structure. We observe that the goods and services we seek are not uniformly available in every urban place; low-order central places may contain the drugstore, the drygoods store, the filling station. We must journey to higher-order central places to secure banking services, medical services, access to the department store, or enjoyment of the cinema. A great many centers perform the most commonplace of these functions, while the more highly specialized activities--demanding a very large total area in population to support them--are localized in only a very few of the nation's cities. One consequence of this apportionment of central place functions among individual urban places is the creation of the regular hierarchical pattern of urban sizes which, in turn, is a fundamental constituent of the composite rank-size pattern already examined. The theoretical work of Walter Christaller, as summarized by Ullman, clarifies this point.

Theoretical and empirical studies within this country and abroad, in areas where urban centers dominantly function as central places, suggest not only a regular size hierarchy among urban units but, as well, a regular spacing pattern. Because of a similarity of level of functional performance, a distinct size clustering of cities is revealed. It is usually concluded that when "central places" dominate the urban pattern, town classes are few in number and the functional and size gradations between the classes are large. At the same time, a dominantly "central place" hierarchy of cities results in a distinctive urban <u>spacing</u> pattern.

:

Granting certain assumptions of uniform agricultural productivity of a topographically homogeneous surface, a regular and distinctive urban spacing and size hierarchy will theoretically develop. Hypothesizing the k = 3 network (a network predicated upon the idea that there is no channelization of movement, and each central place is uniformly accessible from the surrounding countryside) a regular pattern of town sizes should develop. Low-order towns will provide the most common of functions required by the surrounding non-urban populations; successively higher-order communities will house functions requiring ever larger populations and purchasing powers ("thresholds") to support them. We, therefore, see the theoretical development of a multi-level network of urban centers made up of a number of very small market towns, providing a limited number of commonly-needed goods and services for a restricted hinterland; superimposed upon this basic matrix are a succession of higher-order communities providing goods and services requiring larger "supporting" populations.

Theoretically, the smallest towns in any given region will be located a constant distance, a, away from their nearest neighbors. That basic distance, a, will be determined by the acceptable travel distance from hinterland to center. Under the k= 3 network (k = the number of lower-order places dominated by a center in the next higher order), centers in the next higher central place category will be located at a distance equivalent to a times $\sqrt{3}$ and the theoretical distance separating centers of each higher category would increase by $\sqrt{3}$ over that of the preceding category. Such space relationships, granting differences in world population densities and agricultural productivity, have been observed in several sections of western Europe, and the United States.

Required Reading

Charles T. Stewart, Jr. "The Size and Spacing of Cities," in Mayer and Kohn, Readings in Urban Geography, pp. 240-256.
Ullman, "A Theory of Location for Cities," ibid., pp. 202-209.

Brian J. L, Berry and William L. Garrison, "Alternate Explanations of Urban Rank-Size Relationships," ibid., pp. 230-240.

INTRODUCTION TO HUMAN ECOLOGY

(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 36. The Classical City of the Industrial Era (Fellmann)

Central place theory, as suggested in a previous lecture, is based upon the concept that there exists a set of nodal places which serve as centers for diffusion and distribution of ideas, services, and goods which meet demands of a population in complementary regions both within and without central places; and that the central places are arranged in a hierarchy with respect to each other. This hierarchy is spatially arranged in such manner as to maximize the satisfaction of the needs of the population within the complementary region (alternatively known as: hinterland, trade area, service area, tributary area, etc.). The varying levels of functions performed by central places create a regional hierarchy of central places. Each function has a "threshold" requirement, or minimum size of complementary region, below which it will not be economically justifiable. The "nesting" of each successively lower threshold within complementary regions of higher order functions and, where justifiable, the duplication of thresholds within larger regions, give rise to a spatial ordering called the "central place hierarchy."

The idealized size hierarchy and spatial pattern of urban centers subsumed under central place theory can only be achieved where the regional economy is dominated by agricultural activities. Introduction of nonagricultural (*i.e.*, non-central place) functions for cities suggests inevitable departures from idealized central place patterns.

Industrialization has been a chief distorter of classical central place urban size and distribution patterns. Central places display a limited number of concentrated, but highly segregated, size classes; industrialization--by adding new functions and, therefore, new population supporting capacities--tends to blur central place size disparities. In addition, industrial functional orientation to market, transportational, and raw material considerations results in the effectual abolition of uniform spacing patterns presumed by central place theory.

The working population of an urban community is usually assumed to be divided into two groups: one engaged in activities essential to the support and growth of the community, without whose efforts money would not be brought into the urban unit. These have been variously called "primary" workers, "urban growth" workers, or "basic" workers. One dependent upon this first group, but needed by them as well, is that population engaged in "secondary," "support," "service," or "non-basic" activities.

The former by their efforts presumably earn the income required by the community as a whole to purchase commodities not produced by the community itself and purchase the raw materials essential to the functioning of that community. The latter reputedly are supported by the surplus earnings of the primary workers and provide those primary workers with services they do not choose to perform for themselves--retailing, public administration, teaching, etc.

Whatever the validity of this assumed internal employment structure, it is usually agreed that any individual urban unit has one or a series of dominating external functions to perform: manufacturing, retail trade, professional service, transportation or communication, personal service, administration, wholesale trade, finance, mining, and--generally in the case of larger metropolitan centers--diversified functions, with no single activity dominant. Varying objective and subjective techniques have been proposed for determination of dominating city functions.

Whatever they may be, and however their relative dominance may be determined, urban functions are performed by variously specialized populations within a rigidly structured land use environment. Leaving aside considerations of topography and historical accident, that land use environment is strongly conditioned by competition for individual parcels between alternative uses, by transport media available, by non-economic social decisions embodied in land use, by subdivision control and zoning ordinances, and by such external control media as existing street pattern, concepts of prestige, etc.

Within the capitalistic industrialized city developed during the mass transit era, a distinctive and recurring land use pattern developed. That city is best characterized as being compact, of high density, of irregular shape, and showing a sharp division between urban and non-urban uses on its periphery.

Compactness derived from the necessity to minimize separation of place of residence and place of employment. High density resulted from multiple decisions designed to minimize that separation. Irregular outline was the consequence of differential peripheral accessibility based upon location of mass transit lines. Compactness and sharp division between urban and non-urban uses were the consequence of the foregoing conditions.

Within the pre-automobile city, the repetitive structure and hierarchy of land uses was strongly affected by competitive pressures. Rent theory holds that any parcel will, ideally, be occupied by that parcel's highest and best use; such use of determined by the rent-paying ability of various uses seeking occupance of the parcel. The valuation placed upon a particular parcel by alternative uses is a reflection of differential evaluations of income production (or other gratifications) expected to be realized from location at

that site. An economically perfectly adjusted land use structure is not to be expected; inertia, nonproductive public requirements, or even incorrect accounting procedures may lead--within the short run--to land use maladjustments.

The land use structure is strongly affected by accessibility and by the economic resources of potential users. In the pre-automobile western city, mass transit lines radiated away from the original settlement site; as a consequence of focusing of transit upon that site, superior accessibility within the developing urban area was created and continued. Those uses most demanding of--and most able to benefit from--that differential accessibility gradually displaced alternative uses within the central area. The central business district, therefore, developed. Within that CBD, requiring the ultimate in accessibility from all portions of the developing urban unit, an internal stratification of land uses developed. Closest to the focal point of mass transit lines was developed a "mass-buying" area of department stores, specialty stores, and allied activities. In other locations--also economically and functionally determined--developed other land use concentrations: the financial and administrative district, the hotel concentration, the amusement area, etc.

But other locations within the urban area also had superior accessibility--most notably at the crossing of mass transit lines outward from the city center. At such locations subordinate business concentrations also tended to develop. Indeed, the central place hierarchy previously noted as obtaining in areas dominated by an agricultural economy can be seen to exist within the built-up metropolitan area. The highest order central place in the urban scene is the central business district; subordinate to it are major outlying business centers, neighborhood business districts, and finally the "corner store." Breaking up that theoretical central place hierarchy are the "business thoroughfares"--more the result of zoning decisions than of economic responses.

The mass transit city is, from a land use standpoint, presumed to be the result of a complex interaction of rational growth patterns, historical accidents, and perhaps irrational individual or public decisions. Hoyt has suggested a pattern of urban growth in which like uses radiate from the city center along particular avenues of access. Fixed mass transit media or other lines of access give differential accessibility to a limited number of peripheral locations. High quality residential areas--representing occupance most able to bear the cost in time and money of long distance commutation--presumably grow outward along these lines.

Therefore, from the standpoint of residential land use, the developing urban area shows a digitate outline. Closer in to the city center are residential areas either abandoned by higher income groups or originally occupied by lower

income groups not so able to afford the time and money for long distance movement to places of employment. Similarly, industrial areas would tend to grow outward along transport lines of significance to them--waterfronts, river valleys, railroad lines.

Colby, by invoking the concept of centrifugal forces in urban development, hypothesizes an urban unit constantly in flux with frequent movement--both inward and outward--of urban functions responding to pressures of prestige, efficiency, legal restraints, etc. Burgess and Ogburn see the idealized city--located on the flat plain--as composed of a series of concentric circles, each representing a different land use: the internal central business district, a surrounding light manufacturing and wholesaling area, a deteriorating slum residential area, a zone of workingmen's homes, etc. Harris and Ullman see the urban land use structure in more complex terms; to them, the city is a multi-nucleated structure in which individual outlying centers of growth--each of specialized function--have expanded until coalescence created the present observed city form.

Required Reading

Chauncy D. Harris and Edward L. Ullman, "The Nature of Cities," in Mayer and Kohn, Readings in Urban Geography, pp. 277-286.

Richard U. Ratcliff, "The Dynamics of Efficiency in the Locational Distribution of Urban Activities," ibid., pp. 299-324.

John W. Alexander, "The Basic-nonbasic Concept of Urban Economic Functions," ibid., pp. 87-100.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 37. The Emergent Urban Community (Fellmann)

The previously described idealized pre-automotive capitalistic city does not have a direct counterpart in the developing urban form of the Communist world. It depends for its pattern and form upon a free market in land; where such a market does not exist, and where planned allocation of land uses obtains, different internal urban structures are developing. While dominated by mass transit, the Soviet city places a social or cultural--rather than economic--premium upon accessibility. Proximity of place of residence and place of employment is a paramount consideration in allocation of land uses; distributional (commercial) uses are arranged in accordance with populations requirements, but do not assume the same hierarchical structure as within western cities.

The central business district is minimized--its central location taken by governmental offices, memorial parks, and cultural buildings--and commercial uses are, by plan, more uniformly distributed within the residential areas. These latter do not assume the same hierarchical structure as within the western world. Although high density (apartment) housing is the rule, it is organized within "micro-regions" designed to house between four and ten thousand persons and located in close proximity to place of employment. Such "micro-regions" closely resemble the "neighborhood units" of former western planning standards.

The traditional western mass transit city, already described, has been undergoing material change. The American city is a prime case in point, though under differing economic and political circumstances the West European city is following suit. Within the United States, the potential for the development of a new type of city was inaugurated during the 1930's. The introduction of national labor laws instituting the 40-hour work week made home ownership thinkable; the establishment of FHA mortgage insurance made ownership possible; the development of the reliable long distance automobile made home ownership feasible for the majority of the population.

These three factors, in combination, spelled the end of the mass-transit, compact, high density city; for it, there was substituted the sprawled, non-focused, metropolitan urban complex.

Suburbanization in the mass-transit era involved the development of high density outlying communities clustered like beads on a string along commuter railroads; this pattern of discrete, high density communities radiating outward from the central city was in part broken up by the introduction--in the latter part of the 19th century--of electric inter-urban lines able to support a lower density (though still linear) population pattern. The automobile made possible the filling up--at much lower densities than formerly--of interstitial areas formerly non-urbanized because of inaccessibility.

The consequence has been--from the residential standpoint--the development of the sprawled metropolitan area, in which the dividing line between urban and rural is frequently obscured. The consequences of such urban sprawl are significant in shaping the contemporary urban environment. In certain sections of the country--as in northeastern United States (and elsewhere by developing tendency)--the outward growth at low density of formerly separated metropolitan centers is creating "Megalopolis." The multiplication of individual governing and taxing units within a single functionally integrated metropolitan complex is creating urban divisiveness and inefficiency.

The contemporary pattern of suburbanization results materially in lower urban densities. 100 years ago, a growth of 1,000 in the population of a city meant only about a ten-acre addition to the total urban area; such an increase at the present time means an addition of between 100 and 200 new acres. The consequences are material increases in the cost of providing urban services of an acceptable level to the greatly dispersed suburban populations of the nation. Such populations, increasingly housed in specialized (i.e., functionally unbalanced) communities, have decreasing ability to "pay their own way."

Nevertheless, these suburban communities have constantly been augmented by out-migrants from the central city. Within the last ten years, all but two of the country's ten largest cities have lost population; in the suburban and fringe areas associated with those eight declining central cities, population growth was in every case more than thirty per cent. Such major population redistribution has been associated with major cultural and social realignments. Increasingly, the central city is being abandoned to a population composed primarily of non-whites, low-skilled in-migrants, and the impoverished elderly.

Simultaneously, the basic land use structure of the central city and the metropolitan area is undergoing material change. Not only residential, but also commercial and industrial land uses are suburbanized. Such outward migration of economic functions has not only eroded the tax base of central cities, but has additionally and substantially altered previous hierarchical structures of commercial land uses and the former linear pattern of industrial uses.

Suburbanization in the mass-transit era involved the development of high density outlying communities clustered like beads on a string along commuter routes; this pattern of discrete, high density communities radiating outward from the central city was in part broken up by the introduction--in the latter part of the 19th century--of electric inter-urban lines able to support a lower density (though still linear) population pattern. The automobile made possible the filling up--at much lower densities than formerly--of interstitial areas formerly non-urbanized because of inaccessibility.

The consequence has been--from the perspective of planning--the development of the sprawled metropolitan area, in which the dividing line between urban and rural is frequently obscured. The consequences of such urban sprawl are significant in shaping the contemporary urban environment. In certain sections of the country--as in northeastern United States (and elsewhere by developing tendency)--the outward growth at low density of formerly separated metropolitan centers is creating "megalopolis." The multiplication of individual governing and taxing units within a single functionally integrated metropolitan complex is creating urban divisiveness and inefficiency.

The contemporary pattern of suburbanization results inherently in lower urban densities. 100 years ago, the growth of 1,000 in the population of a city meant only about a ten-acre addition to the total urban area; such an increase at the present time means an addition of between 100 and 200 acres. The consequences are substantial increases in the cost of providing urban services of an acceptable level to the greatly dispersed suburban populations of the nation. Such populations, increasingly housed in specialized (i.e., functionally unbalanced) communities, have decreasing ability to "pay their own way."

Nevertheless, these suburban communities have constantly been supplemented by out-migrants from the central city. Within the last ten years, all but two of the country's ten largest cities have lost population; in the suburban and fringe areas associated with these eight declining central cities, population growth was in every case more than thirty per cent. Such major population redistribution has been associated with major economic and social realignments. Increasingly, the central city is being abandoned to a population composed primarily of non-whites, low-skilled immigrants, and the impoverished elderly.

Simultaneously, the location and structure of the central city and the metropolitan area is undergoing drastic change. Not only residential but also commercial and industrial land uses are suburbanized. The outward migration of economic functions has not only eroded the tax base of central cities, but has simultaneously and substantially altered previous hierarchical structures of commercial land uses and the former pattern of industrial areas.

Within the central city the land use pattern has recently been primarily affected by urban planning and land-use zoning; within peripheral areas and suburbs, subdivision control ordinances have been dominating in determining the future configuration of the community. Urban planning--as expressed particularly in urban redevelopment within the metropolitan area--is the contemporary substitute for market forces in shaping the central city.

The replacement of high-density, informal, and economically determined slums by high-density, planned, formalized potential slums is a distinctive feature of modern American urban planning. As a direct consequence of both planning decision and market forces, the central city is becoming an environment of contrasts: of subsidized public housing for low income minority groups, incapable of self-support at an adequate living standard, and of high income housing occupied by prestige groups.

Increasingly, the American urban pattern--the environment of the majority of American citizens--is economically and functionally distressed. Within "suburbia," financial resources on an individual community basis are inadequate to meet the expectations of dominantly residential communities. Within the central city, loss of function--and therefore erosion of tax base--presents a classic urban dilemma. The solution, we are told, lies in planning; the important unasked question is: "Planning for what?"

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369,
Physiology 369, Sociology 369, Veterinary Science 369, and
Zoology 369)

Lecture 38. Applied Human Ecology: Principles of Epidemiology (Levine)

All animals and plants have their own ecologies. Epidemiology deals with the interactions between the ecologies of man and other large animals and those of their parasites.

A parasite is an organism which lives on or within some other organism, drawing nutriment or benefits from it. The organism on which it lives is its host. The difference between a parasite and a predator is one of size--a parasite is smaller than its host. Parasites may or may not harm their hosts. Some may even help them or be necessary for their existence. Symbiosis is the relationship between host and parasite in which the two partners are dependent on each other for existence, such as the relationship between termites and their protozoa. Mutualism is a similar beneficial relationship which is not obligatory, such as the relationship between ruminants and the bacteria and yeasts in their rumens which manufacture B vitamins. Commensalism is the relationship in which the parasite never harms the host but derives benefit from it. Parasitosis is the relationship in which the parasite harms its host, and parasitiasis is the relationship in which the parasite could harm its host but doesn't, usually because it isn't present in large enough numbers. Parasites may be viruses, bacteria, fungi, rickettsiae, protozoa, helminths (worms) of various sorts, insects, mites, ticks, etc.

The environment of the parasite is the host. The host is a microcosm; it is the parasite's ecosystem (or perhaps its biocenose). The parasite's greatest problem is getting from one host to another, and the study of this process comes within the field of epidemiology.

Epidemiology may be defined as the study of disease in its natural habitat, or as the study of the factors governing the occurrence of disease or abnormality in a community or population group. These factors include the characteristics of the population, of the causative agent, and of the physical, biological and social environments. In other words, epidemiology is medical ecology.

Diseases may be infectious (measles, influenza) or noninfectious (diabetes, pellagra). They may affect man either (1) directly, or (2) indirectly by affecting his livestock, pets or food plants. Infectious disease is the result of imbalance in the parasite's ecosystem or a parasite population explosion.

PATHWAYS OF DISEASE TRANSMISSION

I. Vector absent

A. Direct contact.

1. Finger-borne.

Trachoma, childbed fever, human cowpox (thru milkers' hands), bovine streptococcal mastitis (thru milkers' hands), pinworms.

2. Body contact.

Pediculosis (lice)

3. Biting.

Rabies.

4. Kissing

Vincent's angina, common cold.

5. Venereal

Syphilis, gonorrhea, trichomonosis.

B. Transplacental.

Congenital syphilis, toxoplasmosis, some ascarids (roundworms) of dogs and cattle.

C. Air.

1. Dust

Psittacosis, Q fever, pinworms, histoplasmosis, cocciodomycosis.

2. Aerosol or droplet.

Pneumonia, influenza, diptheria, scarlet fever, tuberculosis, pneumonic plague.

D. Water.

Cholera, typhoid, leptospirosis, tularemia.

E. Food.

1. Milk.

Tuberculosis, brucellosis.

2. Mother's milk.

Toxoplasmosis, streptococci septicemia.

3. Solid foods.

a. Infection.

Salmonellosis, typhoid, anthrax, trichinosis, tapeworms.

b. Preformed toxins.

Botulism, staphylococcal food poisoning, ergotism.

F. Soil.

Anthrax, tetanus, erysipelothricosis, maduromycosis, streptothricosis.

II. Vector present.

A. Vectors mechanical.

1. Vectors nonparasitic; transmission by ingestion or otherwise.

Typhoid, various diarrheal diseases (by flies).

2. Vectors parasitic; transmission by biting or otherwise.

Tularemia, anaplasmosis, surra.

B. Vectors biological

1. Vectors nonparasitic.

a. Transmission by ingestion.

Tapeworms, liver and intestinal flukes, spirurid nematodes.

b. Transmission by skin penetration.

Schistosomosis.

2. Vectors parasitic.

   a. Transmission by ingestion.

      Dog flea tapeworm (Dipylidium).

   b. Transmission by skin penetration.

      Chagas' disease (Trypanosoma cruzi).

   c. Transmission by biting.

      Malaria, filariosis, African sleeping sickness (Trypanosoma gambiense, T. rhodesiense), yellow fever, relapsing fever, typhus, scrub typhus, tularemia, plague.

(Note that many parasites are able to use more than one mode of transmission, e.g. tularemia--insect bites, direct contact through infected animals, contamination of food and water).

The pathways of disease transmission are of 2 main types: Transmission with or without a vector (a second species of living organism--ordinarily an invertebrate--which transmits a disease or parasite from one vertebrate host animal to another). The parasite multiplies in a biological vector; it does not multiply in a mechanical vector. If there is no vector, the parasite may be transmitted by direct contact, through the placenta, or through the air, water, food or soil. If the vector is mechanical, the parasite may be transmitted by ingestion, biting or otherwise. If the vector is biological, the parasite may be transmitted by ingestion, biting, skin penetration, etc.

Cutting across this classification is one based on the parasite's host range. Some parasites are stenoxenous; they have a very narrow host range and for practical purposes we can say that they have only a single host species. Diseases caused by stenoxenous parasites are syphilis and the common cold. Other parasites are euryxenous; they have a number of host species, and any of these may act as reservoirs of disease for the others. Among diseases caused by euryxenous parasites are tuberculosis and virus encephalitis. Zoonoses belong to this latter category. A zoonosis is a disease transmissible between man and lower animals.

A disease which involves only a parasite and its host is a 2-factor system. An example might be human pneumonia. The dynamics of pneumonia transmission are not easy to put in mathematical terms. Factors which affect it are: (1) The number of people per unit area, i.e., the concentration of people, (2) the proportions or numbers of susceptible and immune people, (3) the length of time the host disseminates the parasite, (4) the presence or absence of healthy carriers, (5) the parasite's mode of transmission,

(6) the length of time the parasite can survive in the external environment, (7) the distribution of the host population, (8) the types and numbers of interactions between individual hosts, and (9) the general type of environment, urban, suburban and rural.

A disease which involves a parasite, host and vector is a 3-factor system. An example is malaria, which is transmitted from man to man by mosquitoes. Here several new groups of factors are introduced--those dealing with: (1) The infectibility of the vector, (2) the propagation and survival of the vector, and (3) the relations between the host and the vector.

Both of the above systems have to do with stenoxenous parasites. If the parasite is euryxenous, there may be a 3-factor system of another type--involving the parasite, host and a reservoir--or a 4-factor system involving the parasite, host, reservoir and vector. These are zoonoses. The introduction of a reservoir has a marked effect on their epidemiology, which is even more complex than that of stenoxenous parasites.

Required Reading

World Health Organization. The Americas (special issue). World Health. September-October, 1961. 40 pp.

Other References

May, J. M. 1958. The ecology of human disease. MD Publ., New York. xxiv + 327 pp.

Taylor, I. and J. Knowelden. 1957. Principles of epidemiology. Little, Brown. Boston. vii + 300 pp.

Zinsser, H. 1935. Rats, lice and history. Little, Brown. Boston. xii + 301 pp. (This is also Bantam FC55, 1960, paperbound, 50 cents).

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 39. Applied Human Ecology: Malaria and Other Insect-Borne Diseases (Levine)

Malaria is caused by a protozoan parasite which lives inside the red blood cells. It multiplies in the red cells and destroys them when it breaks out to invade new red cells. The parasite's generation time is 2 or 3 days, depending on the species. All the parasites multiply at the same rate and break out of their host cells at the same time, causing the typical malarial paroxysm of chills and fever. After a person has had a number of paroxysms, he ordinarily recovers, but the parasites remain "dormant" in his liver cells and perhaps other organs. Under proper conditions, when he has lost some of his immunity or under stress of some kind, he may suffer a relapse or series of relapses. Mortality from malaria is higher in children than in adults.

The life cycle of the malarial parasite involves both asexual and sexual multiplication. The asexual stages cause malarial fever, but the sexual stages are necessary for transmission, which is accomplished by *Anopheles* mosquitoes. They take up the sexual stages when they suck blood. These then multiply in the mosquito for 10 days or more, and are transmitted when the mosquitoes bite again.

There are 4 species of human malaria parasites (*Plasmodium falciparum*. *P. malariae*, *P. ovale* and *P. vivax*). The characteristics of the disease depend upon the species involved.

There are over 200 species of *Anopheles* mosquitos, but not all of them are equally good vectors, and the epidemiology of the disease in any particular locality depends not only upon the terrain and climatic conditions, but also upon the particular vectors present, their breeding habits, food preferences, susceptibility to infection, etc. The principal vector in southeastern United States is *Anopheles quadrimaculatus*; it breeds best in clean open water with dense aquatic vegetation and abundant flotage; it prefers bovine to human blood, so that the ratio of cattle to man in an area affects the malaria transmission rate. The principal vector in the Solomon Islands is *A. farauti*; it breeds in small ponds, puddles, road ruts, shell holes, fox holes, etc., so it was at its most efficient during the combat conditions of World War II. The principal vector in the Philippines is *A. minimus flavirostris*; it breeds at the edges of slow-moving streams in the plains, so malaria doesn't occur in the mountains of the Philippines.

Malaria is primarily a disease of warmer climates nowadays, but at one time it was common in the temperate zone. It is still the most important human disease from a global standpoint. In 1955 there were still 200 to 225 million cases of malaria in the world, with more than 2 million deaths. Malaria has had a tremendous effect on human culture in many ways. It was one of the causes of the decline of the Roman empire. It has wrecked the plans of armies from time immemorial right through World War II. It was in response to malaria that sickle cell anemia was able to become an important disease of man in tropical Africa and other places; this trait is due to a minor change in the hemoglobin molecule and is controlled by a single gene; the homozygous condition is generally lethal, but heterozygotes are more resistant than ordinary people to falciparum malaria and hence have a biological advantage in areas where malaria is rampant.

Malaria was an important factor in the settlement of the United States.. There were a million cases a year among a population of 25 million in 12 southern states during 1912 to 1915. The disease had been on the decline even then, and it decreased still further due only in small part to measures aimed directly against it. It was almost entirely eliminated from the midwest by farmland drainage. After World War II, an intensive campaign was started to wipe it out. During 1949, less than 5,000 cases were reported in the U. S. In 1958, 94 cases were reported, of which 61 were confirmed; 7 were primary indigenous cases, 4 of them resulting from blood transfusions and 1 natural case originating in California, Arizona and possibly Pennsylvania respectively.

There were no obvious technical or economic reasons why malaria could not be eradicated from the Americas, Europe, Australia and much of Asia during the next 25 years (Alvarado and Bruce-Chwatt, 1962, say 10 years) although the situation isn't so promising in tropical Africa. This can be done almost entirely by residual spraying of dwellings, etc., with DDT. Properly done, residual spraying for 2 to 3 years will eradicate malaria.

The World Health Organization is directing the malaria eradication effort. It estimated in 1959 that the effort would cost $1,691 million. About $90 million a year was spent in 1958 and 1959, and about $103 million in 1960. In 1960 about 1 billion people were living in malarious areas. Malaria eradication was under way at one stage or another in areas where about 700 million people lived, and pre-eradication surveys were being undertaken in areas where 183 million people lived. As of January 1960, malaria had been eradicated from once-malarious areas in 18 countries or territories having a population of 108 million: Barbados, Byelo-Russia (USSR), Chile, Corsica, Cyprus, Gaza Strip, Hungary, Italy, Latvia (USSR), Lithuania (USSR), Moldavia (USSR), Martinique, Netherlands, Puerto Rico, Singapore, Tobago, Ukraine (USSR), United States.

But new problems result from malaria eradication. The death rate goes down, but if the birth rate remains constant, the population will increase rapidly and bring with it the problem of feeding the new millions. In 1920 the birth rate on Ceylon was 40 per 1,000 and the death rate was 32 per 1,000. In 1950 the birth rate was about the same, but the death rate was now 12 per 1,000, and the difference was due in part to malaria control. If both the present birth and death rates are maintained, the population of Ceylon will double in about 26 years.

Required Reading

Alvarado, C.A. and L. J. Bruce-Chwatt. 1962. Malaria. Scientific American 206(5): 86-98.

World Health Organization. 1960. Malaria (special issue). World Health. March-April, 1960. 40 pp.

World Health Organization. 1962. Malaria (extra issue). World Health. 1962.

Other References

Livingstone, F.B. 1958. Anthropological implications of sickle cell gene distribution in West Africa. Amer. Anthrop. 60:533-562.

Macdonald, G. 1957. The epidemiology and control of malaria. Oxford. London. xv + 201 + xl + 11 pp.

Pampana, E. J. and P. F. Russell. 1955. Malaria. A world problem. Chron. World Health Organ. 9:31-100.

Soper, F. L. et al. 1961. Report and recommendations on malaria: A summary. International Cooperation Administration expert panel on malaria. Am. J. Trop. Med. Hyg. 10:451-502.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 40. Applied Human Ecology: New Frontiers in Epidemiology (Levine).

A.

Proteins are in very short supply in tropical Africa, and the natives must live on vegetable foods which are low in protein. Their sources of animal protein are termites, grasshoppers, rodents, some fish, some wild animals, and very few domestic animals. Because of this shortage of domestic animals, the people are subject to a number of special diseases such as anthrax from eating the carcasses of animals which have died of the disease, and mite-transmitted rickettsial diseases acquired by catching and eating wild rats at the end of the dry season. Still more important and widespread is kwashiorkor, a nutritional disease due to protein deficiency which affects children 6 months to 5 years old.

These diseases occur in man in Africa because of another disease-trypanosomosis. They are consequences of its existence in the region. Trypanosomosis is not one disease but a group of related ones which occur in man and domestic animals. It prevents livestock from being raised in significant numbers in some 4 million square miles of sub-Saharan Africa. This creates a deficiency of protein in the inhabitants' diets, and other diseases follow it in train.

Another consequence has been lack of animal transport. This in turn protected the people from conquest and from "civilizing" contacts from the north. Trypanosomosis killed both the people and their riding animals.

The whole culture of the people is different from what it would be without the disease.

Trypanosomosis in man is caused by 2 species of protozoa of the genus Trypanosoma. Both are carried by tsetse flies. Gambian sleeping sickness is a strictly human disease, but Rhodesian sleeping sickness is a zoonosis, with wild game as its reservoir. The protozoa are introduced into the body by the bite of the fly. They multiply in the blood and lymph, and cause a febrile disease. Later on, they may pass into the central nervous system and cause a slowly developing encephalitis--sleeping sickness.

Other species of Trypanosoma cause a group of similar diseases in domestic animals--nagana, paranagana, surra, souma, etc. It is these which have largely prevented livestock from being raised in sub-Saharan Africa. Some are carried by tsetse flies, others by horseflies and deerflies. These are euryxenous diseases, with reservoirs in the wild game, which are not seriously affected by them.

Trypanosomosis can be controlled in man by treating the whole population with drugs whether they appear sick or not--mass chemoprophylaxis--and also by tsetse fly elimination. The same measures can be used to control trypanosomosis in domestic animals, but they haven't been as successful.

But control of trypanosomosis (and malaria) allows the population to increase, and this introduces new problems. The British attempted to grow groundnuts (peanuts) in Tanganyika after World War II in order to relieve the general protein deficiency, but they failed because they didn't take into account such ecological factors as soil fertility, leaching by tropical rains, etc. French attempts to raise cotton after clearing the tropical rain forest also failed for essentially the same reasons. The soil under the lush tropical rain forest is thin and poor, and cannot safely be exposed to massive erosion. In addition, attempts to conserve the large wild fauna of Africa are doomed to failure because of increasing population pressure.

Required Reading

Scrimshaw, N.S. and M. Behar. 1961. Protein malnutrition in young children. Science 133: 2039-2047.

Other References

Ashcroft, M. T. 1959. A critical review of the epidemiology of human trypanosomiasis in Africa. Trop. Dis. Bull. 56: 1073-1093.

Bouillenne, R. 1962. Man, the destroying biotype. Science 135: 706-712.

Brock, J. F. and M. Autret. 1952. Kwashiorkor in Africa. World Health Org. Monog. Ser. #8 78 pp.

Darling, F. F. 1960. Wild life in an African Territory. A study made for the Game and Tsetse Control Department of Northern Rhodesia. Oxford University Press. London. ix + 160 pp.

Dorn, H. F. 1962. World population growth: An international dilemma. Science 135: 283-290.

Lee, D. H. K. 1957. Climate and economic development in the tropics. Harper, New York. 182 pp.

Levine, N.D. 1961. Protozoan parasites of domestic animals and of man. Burgess. Minneapolis. iii + 412 pp.

B.

Most infectious diseases are becoming less prevalent, but schistosomosis (bilharziosis) is becoming more common and is spreading slowly over the earth. It is being propagated by man.

Schistosomosis is caused by schistosomes or blood flukes. These are flatworms (trematodes) which live in the veins in the abdominal cavity. There are 3 important species in man: Schistosoma mansoni occurs in Egypt, Africa, the West Indies (including Puerto Rico) and South America; S. haematobium occurs in Egypt (the lower Nile delta only), Africa, the Near East and Portugal; and S. japonicum occurs in Japan, China, the Philippines and the East Indies (but not in southeast Asia). India is free from human schistosomosis except for a small focus of S. haematobium in Bombay State.

S. mansoni and S. haematobium are confined primarily to man, but S. japonicum also occurs commonly in the pig, horse, cattle, cat and dog; it causes a zoonosis.

In addition to these species, other schistosomes occur in various domestic and wild animals. Some of them may infect man, causing schistosome dermatitis or swimmer's itch (a zoonosis), but they never reach the adult stage in him.

Blood flukes live in the veins of the mesenteries and lay eggs in the small venules in the walls of the colon or bladder. Their location determines the type of disease they cause. S. mansoni and S. japonicum occur in the walls of the colon and cause a disease of the lower intestine. S. haematobium occurs in the bladder wall and causes a bladder disease. It was known to the ancient Egyptians as the a-a-a disease.

To reach the lumen of the intestine or bladder, the eggs erode through the tissues and cause lesions of varying severity. In addition, some of the eggs get into the returning veins and pass to the liver, lungs or other organs, where they are caught in the capillaries and cause small lesions to form. Schistosomosis is generally a chronic, debilitating disease and causes general loss of vigor.

Once the eggs leave the host, they must reach water in order to hatch. They swim actively until they find a snail of the right species. They bore into it and undergo a complicated form of larval multiplication which finally results in the formation of some thousands of free-swimming infective larvae (cercariae) for each original egg. These cercariae swim in the water and enter their final host by boring through the skin.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

The customs of the people and their relation to water are closely related to schistosome transmission. The Mohammedan religion's emphasis on washing after defecation or urination, together with lack of proper sanitary facilities, makes for deposit of eggs in locations where they can readily reach water. And the use of the same water for drinking, bathing and washing serves to help complete the cycle.

The increasing use of irrigation to grow crops needed by our expanding population has brought with it an increase in suitable snail habitats, and this has been accompanied by the spread of schistosomosis. The disease is now present in many regions where it never existed before in North Africa, the Near East, South America and elsewhere. It has spread from the Nile region of Egypt to many oases. Completion of the Aswan High Dam in Egypt will bring with it a greatly increased schistosomosis problem.

Snails are needed for schistosome development, and snail control is therefore the key to schistosomosis control. Snails can be controlled by eliminating their breeding places (by stream and ditch clearing, etc.) or by treating the water with a molluscicide (copper sulfate, sodium pentachlorophenate, barium carbonate, etc.). Other measures include proper disposal of body wastes, avoidance of infested water, and (in areas where schistosomosis is a zoonosis) elimination or control of animal reservoirs. Tartar emetic and other drugs are used in treating the disease, but they are not too satisfactory.

<u>Required Reading</u>

Muller, R. 1961. Bilharzia: The new importance of an old disease. Trop. Sci. 3:6-18.

<u>Other References</u>

Deschiens, R. 1952. Le probleme sanitaire des bilharzioses dans les territoires de l'Union francaise. Monogr. V, Soc. Pathol. Exot., Paris. 100 pp. (Also Bull. Soc. Pathol. Exot. 1951. 44: 350-377, 631-688).

McMullen, D.B. and W. H. Harry. 1958. Comments on the epidemiology and control of bilharziasis. Bull. World Health Org. 18: 1037-1047.

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lectures 41 and 42. Changing Animal Populations to Supply Human Needs (Touchberry)

Modern day farm animals differ greatly from the farm animals of 50 years ago. They belong to the same species and still have a similar outward appearance but in certain functions they differ greatly. In the state of Illinois there are half as many dairy cows today as there were 15 years ago, yet Illinois produces more milk today than it did 15 years ago. Certainly all of this increase in production per cow is not a result of genetic change but a substantial fraction of it is. Our modern day pig is far removed from the fat lard type pig of 30 to 40 years ago. A much larger fraction of the pig's carcass is lean meat and the fat that is present is well distributed throughout the carcass. The layer of fat across the back of our modern pigs is not as thick as that on pigs of 25 years ago. Further, our modern pigs have a higher gain in weight per day, reach market weight at a much younger age and require less feed to reach market age. In the last 15 years the changes in broilers relative to rate of gain, pounds of feed per pound of gain, and resistance to disease have been spectacular. The modern day hens are far superior to their predecessors as producers of eggs. Similar phenomenal changes have occurred in making turkeys extremely efficient meat producers.

These changes were directed toward efficiently supplying the needs and wants of man. They did not occur by chance but are the results of applying scientific knowledge to the solution of one of man's most important problems: that of acquiring ample, high-quality food. Scientific knowledge from the fields of Nutrition, Genetics, Physiology and others was used in bringing about changes in our animals. The fact that we are able to efficiently produce large quantities of high quality food and fiber has helped to make the United States one of the world's leading countries.

The lectures will explain how genetics was used in changing our domestic animals to provide the needs of modern man and how it can be used to provide future needs. All animal populations have characteristic gene frequencies and genotypic frequencies. To change a population from a state that is not desired by man to one that is, involves changing the gene frequencies or the genotypic frequencies or both.

To change the gene frequencies man must rely on selection and migration. Mutation is a means of changing gene frequency but to date it is a feeble force and cannot be controlled so as to cause change in a given

direction. Mutation is thus more of a proposing force to bring new variations into a population. Selection and migration are disposing forces and act on variations that are present in the population. Selection may be defined as a differential rate of reproduction in which individuals with desired characteristics are allowed to reproduce at a greater rate than those lacking or deficient in these traits. Progress from selection depends on how much those chosen to be parents exceed the mean of the population from which they were chosen and the heritability of the trait or traits involved. The rapidity with which selection can change a population depends on the reproductive rate and the generation interval.

Migration is defined as moving animals from one population to another. Genetic changes brought about by this process depend on the amount by which the populations differ in gene frequencies, the number of animals moved and the relative reproductive rates of immigrant and native animals.

Required Readings

Falconer, D. S., Quantitative Genetics, pp 1-46 and 185-207 Ronald Press, 1960. (Call Number 575.1 - F186)

(Copies are in the Agriculture and Biology Libraries).

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 43. Applied Human Ecology: Food-Population Interactions (Harshbarger)

Food, space, and climate constitute the ultimate limiting factors on the population size attained by any species (See Lecture 15--Dr. Kendeigh). The present discussion treats the food-population (human) interaction in terms of: (1) world population, present and projected, (2) world food production, yields and patterns, (3) efficiencies of food-production practices, and (4) modifications of food-production patterns in response to future demands.

1. Population-Food Adjustments. Man requires food for body maintenance, growth, and physical effort. His maintenance and growth requirements are relatively stable, whereas the energy requirements vary somewhat with physical effort and age. In general, however, food consumption requirements are remarkably stable. Also, they are on a day-to-day basis as the human body can store little food. Therefore, the factors which adjust food supply to the population and the population to the food supply, either on a short- or long-term basis, are worthy of consideration.

Among the major factors which adjust the population are: (a) birth rate, (b) famine, (c) war, (d) disease, and (e) migration. Adjusters of the food supply include: (a) production, (b) export-import, (c) storage, (d) intensified cropping systems, (e) livestock, (f) alternative uses of food, and (g) prices. These and other adjusters must be considered in the solution of population-food problems (Pearson, F.A. and Paarlberg, D.).

2. World Population. The rate at which a population grows is determined by the difference between the birth rate and the death rate. Within the past century the population level has increased rapidly to $2.6X10^9$, but more important, the rate of increase has also accelerated. Between 1850 and 1900 world population grew about 0.7 per cent per annum; equivalent to a population doubling each 100 years. Between 1900 and 1950 the average rate of increase was 0.9 per cent; equivalent to a doubling time of 75 years. Between 1950 and 1980 the rate of increase is estimated to be about 1.3 percent annually; equivalent to a doubling time of 50 years. (Brown, Bonner and Weir). Although the world pattern shows relatively high rates of population growth in much of the world, growth rates bear little relationship to gross national product per capita (Ginsburg). The less prosperous countries are found on both sides of the mean rate of 1.6 per cent per year.

However, the majority of such have rates in excess of the mean.

3. World Food Production. Approximately one-half of the $2.6 X 10^9$ people of the world receive a daily food intake of less than 2250 calories; about 20 per cent receive between 2250 and 2750 calories; and about 25 per-cent receive in excess of 2750 calories per day (Brown et al). The world pattern suggests that countries with the higher GNP/capita, i.e., greater developed wealth, have larger food supplies for their populations, and presumably more productive labor forces. The reverse is true of the poorer countries, and the data indicate that about 56 per cent of the world's people subsist on a daily food intake of less than 2000 to 2250 calories, a level considered a minimum by some nutritionists (Ginsburg).

The patterns of food production differ greatly throughout the world, especially in the varying degrees to which animal products are included in the diet. The inclusion of animal products in the diet--35 per cent in the United States, less than 5 per cent in Asia--is a reflection of the capacity of an economy, in terms of productivity and population pressures, to select between conversion of plant materials via animals or the direct consumption of such materials to reduce wastage and increase efficiencies (Brown et al).

4. Food-Production Efficiencies and Changing Patterns.

It has been estimated that increases in food supply commensurate with population demands are attainable by wider application of present technology. Productivity can be increased by 2 to 4 per cent per year by use of more irrigation, more fertilizer, more insecticides and rodent control, by application of more plant-improvement techniques, and by practicing more intensive agriculture along the lines used in Japan. Conventional agriculture should suffice to feed 7 to $8 X 10^9$ people, but at standards lower than those of the best fed people today (Brown et al).

Required Readings

Brown, H.A., Bonner, J., and Weir, J. The Next Hundred Years, The Viking Press, N.Y., 1958, Ch. 7, 8, 9, 10.

Clark, F. L., and Pirie , N.W. Four thousand Million Mouths. Oxford University Press, New York, 1951.

Ginsburg, Norton. Atlas of Economic Development. Univ. of Chicago Press, 1961. Tables 2,3,4,5,6, 9.

Pearson, Frank A. and Paarlberg, Don. Starvation Truths, Half-Truths, and Untruths. N.Y. State College of Agr., Cornell Univ.,Ithaca, N.Y. 1946.

famine, the majority of such lives being in excess of the ration.

3. Trends in Food Production. [illegible] roughly one-half of the people of the world receive a daily intake of less than 2250 calories, about 30 per cent receive between 2250 and [illegible], and about [illegible] per cent receive in excess of [illegible] calories per day (Bennett et al.). The world pattern suggests that countries with low figures (2250/capita), i.e., underdeveloped countries, are [illegible] and [illegible] presumably [illegible] countries, and [illegible] per cent of [illegible] subsist on a daily food intake of less than [illegible] calories, a level considered [illegible] necessary.

The [illegible] greatly throughout the world, [illegible] in the [illegible] to which [illegible] products [illegible] the diet. The [illegible] of animal products in the diet [illegible] in the United States, [illegible] per cent [illegible] of an economy [illegible] between conversion of plant [illegible] or the direct consumption of such crops [illegible] (Bennett et al.).

4. [illegible] Production [illegible] and Current Trends.

It has been estimated that increases in food supply commensurate with population demands are [illegible] with application of present technology. [illegible] increased [illegible] per cent per year by use of [illegible], more fertilizer, [illegible] insecticides and rodent control, by application of [illegible] techniques, and by [illegible] along the lines used in Europe. [illegible] should [illegible] the best [illegible] (Bennett et al.).

Suggested Readings

Bennett, [illegible], and [illegible]. [illegible] New York, [illegible], 1955, Ch. [illegible].

Clark, [illegible], and [illegible]. [illegible] Press, New York, [illegible].

[illegible] Univ. of Chicago Press, [illegible]. Volume [illegible].

[illegible] and [illegible], N. Y. State College of Agr., Cornell Univ., Ithaca, N.Y. [illegible]

INTRODUCTION TO HUMAN ECOLOGY
(Anthropology 369, Geography 369, Health Education 369, Physiology 369, Sociology 369, Veterinary Science 369, and Zoology 369)

Lecture 44. Concluding Remarks: Emphases and Limitations of the Course; Further Perspectives in Human Ecology (Shimkin)

In the concluding remarks, we shall try to summarize some salient features of the course, to indicate its basic limitations, and to suggest areas of ongoing and needed work in human ecology both at the University of Illinois and elsewhere.

1. Selected emphases. In general, the course has been an examination of large aspects of human biology and of culture from the standpoint of a limited number of hypotheses. In the course of this examination, the first area of emphasis has been on the roles of the physical environment. These have been manifest in setting physico-chemical conditions permitting life; for example, a temperature and gravitational relationship in which water is liquid. In addition, environmental variations, by place and over time, have set limits to the possibility of certain kinds of life and developed great selective pressures upon the evolution of all types of life. In this regard, Shelford's concept of ecological preferenda, under which species reach maximum density, provides a unifying generalization. Another important generalization is that life modifies the physical environment, acting generally as a catalyst in the selective concentration of energy and matter; in principle, man's modification of his environment is not different from that exercised by anaerobic bacteria.

2. The second area of emphasis has been the definition of general requirements for the maintenance of life, especially among multicellular terrestrial animals. Here, the guiding principles have been those of homeostasis and self-regulation. In other words, adaptation is visualized as the approach to optimal conditions made possible by sensing and controlling devices governing the entire organism. Also important is the fact that organisms operate through time with rigorously defined life sequences changing requirements and adaptive capacities. Moreover, cyclicity--for example, sleep and waking--is characteristic of all biological processes; hence, the nature of a steady state must be regarded essentially as a reverberation. The greatest degree of transformation in every life sequence is manifested in sexual polymorphism. Each complex animal reproduces only at the stage of the single-cell sperm and egg and appears generally in a dimorphic form. These phenomena profoundly affect the stability of populations through the

process of meiosis and also through the intense selection which takes place among sperm and eggs, a selection more severe by far than at any other point in the life sequence. Sexual behavior also is the foundation of socialization which, in turn, changes selection mechanics profoundly in comparison with purely competitive populations. Populations, in general, are the essential units of biological persistence and of genetic selection.

3. Thus far, our attention has been on a wide variety of higher animals. Among the mammals, particularly, the major peculiarity has been a great development of the central nervous system and, especially, an increasing one of reception and control via the cerebral cortex. Allied to this have been the fundamental phenomena of wakefulness of choice and self-stimulation. In man, these attributes are enhanced by major capacities to inhibit physiological drives and to symbolize them through displacements or other types of substitute gratifications.

4. Man, in common with all other forms of life, lives as part of a multi-species biological community. At the very minimum, each community must contain both plants, acting as primary fixers of solar energy via photosynthesis, and animals recycling plant nutrients into the soil. Biological communities rest, in general, upon a division of labor between species and upon a hierarchy of dependencies founded upon dominant species which determine the character of the community, receive the impact of the climate, and set up favorable niches for subdominant species. Man has achieved dominance by the use of external energies and tools, in particular, through land clearance, selective extermination and the selective breeding of tamed species. Nevertheless, man's communities are not independent of the natural biomes. Civilization has flourished largely in natural areas of deciduous forest and grassland; almost without exception, human climax-communities or metropolitan areas are located contiguous to large bodies of water--on rivers, lakes, or the sea. In general, the most fundamental control of nature over man still operative is that of water supply.

5. Water supplies are essential in modern civilization both as the largest single flows in industrial processes and as the largest single inputs into food production. Systems of food production have developed very markedly in the last 40,000 years and have become increasingly reliable and less demanding of labor per unit of food produced. Conversely, food production has become extremely dependent upon precise biological selection, upon the reduction of competing species, and upon the input of stored capital. Because of these technological variables and because of the varying impact of different sociopolitical arrangements, food-producing systems vary largely in their efficiency and reliability under equivalent geographical conditions. Thus, Indian agriculture is several times less efficient in yields of calories per acre than South Chinese or Japanese. American agriculture is less efficient than West European but more so than that of the Soviet Union. This variation among efficiencies contributes very largely to regional deficiencies in food supply.

process of natural and then through the rigorous selection which takes place among [illegible] the [illegible], [illegible] more [illegible] at one other point in the [illegible] social behavior [illegible] the [illegible] social [illegible] which [illegible] [illegible] in comparison with purely [illegible] [illegible]. [illegible] in general, are the original units of biological [illegible] and of genetic selection.

3. Thus far, [illegible] has been [illegible] wide variety of higher animals. Among the mammals, particularly, the [illegible] has been a great [illegible] of the central nervous system and, more [illegible], an increasing use of [illegible] and control via the cerebral cortex. Along with these [illegible] the fundamental [illegible] of [illegible] and [illegible] [illegible]. In many [illegible] are [illegible] of [illegible] [illegible] and to symbolize them through [illegible] or other types of [illegible] gratification.

4. [illegible] with [illegible] as part of a multi-species biological community. [illegible] community [illegible] with [illegible], [illegible] [illegible] of [illegible] plant synthesis, [illegible] [illegible] [illegible] into [illegible]. [illegible] upon [illegible] of [illegible] species which [illegible] of the community. [illegible] niches for [illegible] species, [illegible] [illegible] [illegible] and [illegible] of [illegible] species. [illegible] [illegible] of the [illegible] [illegible] almost without [illegible], [illegible] [illegible] bodies of water, [illegible]. In general, the most [illegible] control of [illegible] is [illegible] supply.

5. [illegible] are [illegible] largest [illegible] in [illegible] and in the [illegible] into food [illegible]. [illegible] of food production [illegible] in the last 40 [illegible] [illegible] of [illegible] per unit of food produced. [illegible] has become [illegible] dependent upon [illegible] upon the [illegible] of competing species, and upon the [illegible] of [illegible] [illegible] and [illegible] of the [illegible] of [illegible] efficiency and [illegible] under [illegible] conditions. [illegible] [illegible] than [illegible] Chinese or Japanese. [illegible] than [illegible] European but [illegible] of the [illegible]. This [illegible] among [illegible] contributes very largely to [illegible] in food supply.

6. Increasing efficiencies in food production, together with the development of techniques of food preparation and storage, have permitted the allocation of increasing shares of total human resources and effort to other activities. However, as late as the 18th century, the highest efficiencies reached were those in which four farmers could support five people; hence, urbanization, government, religion, warfare and other developments of culture were considerably limited in their scope. Since that time, the increasing efficiency of agriculture has made possibly essentially total urbanization so that, in the United States, agriculture, itself, comprises a specialized industry within the intense division of labor of the total economy. Coincident with this phenomenon has been the physical and structural expansion of cities, not only in terms of greater areas of settlement but also in terms of expanding hinterlands. From that standpoint, the city of New York extends 100 miles to the north in reflection of the source of its water supplies. The entire Mississippi River must be regarded in some ways as an appendage of Chicago--its outlet for waste disposal. The city relates to the natural environment in a very specialized and mediated way. Its inhabitants are protected from direct environmental stress but, on the other hand, are still subject to general disturbances. For example, in the early 1950's, world-wide drought gravely disturbed the entire functioning of cities such as New York. With increasing pressure on water supplies, future drought cycles are likely to produce even more serious effects. Water pollution, through sewage, industrial waste and the ubiquitous detergents, threatens not only waterfowl but man himself. Similarly, cities have subjected themselves to increasing general problems of air pollution which adversely affect the life prospects of man and vegetation alike. Thus, the mediation of the city has been one of making the natural habitat a less selective, yet still pervasive, force in human affairs.

7. The human social environment operates primarily on two distinct planes--common needs and aspirations intensified by mass communications, and specialized roles and differential mobility, particularly related to educational opportunity. In the context of a city, economic specialization can be maximized so long as information on available specialties is readily retrievable through quasi-random access, i.e., by telephone directories. Economic specialization of a high order is constantly being counteracted by technological changes rendering skills obsolete. The efforts of the upwardly mobile to break down social controls, and of those threatened economically to maximize them, are reflections of this basic economic competition. These conflicts and internal changes, augmented by the effects of physical migration to and between cities, generate characteristic social instabilities and problems, along with new creative and regulatory capacities. In sum, the ecological functions of cities and their inherent difficulties in all industrial societies are closely linked.

Questions of Application.

The models and analytical techniques of ecology are useful means of approaching a wide variety of practical problems. The oldest area of

Increasing efficiencies in food production, [illegible] development of techniques of food preservation and storage, have permitted the allocation of increasing shares of total human resources and energies to other activities. [illegible] efficiencies resulted when types of [illegible] transportation [illegible] were commonly [illegible] Since that time, the increasing efficiency of [illegible] that, in the United States [illegible] industry [illegible] of the [illegible] with [illegible] in terms of [illegible] Chicago— [illegible] very [illegible]

[illegible]

[illegible] Environment.

[illegible]

ecological application is that of epidemiology wherein the work of Gorgas on yellow fever, more than 50 years ago, showed the decisive effect of breaking just one link in the infectious cycle. Epidemiology has been applied with great success to a large variety of infectious diseases. Today, the problems of mental health have begun to be viewed from an epidemiological standpoint, with the work of Lawrence Hinkle and his colleagues of the Cornell medical school being especially notable in this regard. Another new frontier in epidemiology is that in cancer. Cancer undoubtedly is a complex phenomenon involving differential susceptibilities, particular environmental conditions, and specific activating agents. The etiology of a few types of cancer has been rigorously defined, e.g. skin cancer in relation to ultraviolet radiation. For the great bulk of neoplasms, the etiology is unknown and the present task, vigorously pursued by the National Cancer Institute and other agencies, is one of combining appropriate ecological field studies with refined laboratory techniques to set up and test decisively a variety of models. Most recently, physical agents and viruses have been joined by fungi as identified causal agents.

The other great dimension of ecological application is in the rational management of resources--land, energy, manpower, etc. This rationality necessarily involves not only considerations of a limited optimization for a limited time period but also a deep concern for the maintenance of adaptive capacities for future generations. In this regard, managerial choices which irretrievably damage future potentials, e.g. the reckless extermination of species through uncontrolled pesticidal use, must be viewed with alarm. Also crucial is a recognition that the greatest area of rational management today is that of human self-regulation, including the extremely great need for the control of population growth. Thus, the problems of ecology in their applied form involve not only the elimination of given afflictions, e.g. aftosa, but the invention of more efficient and flexible systems, codes and the like, for the development of desired new equilibria.

Research Problems and Potentials.

"Introduction to Human Ecology" has strived to be an initial guide to a large literature and to a considerable body of concepts rather than a closed, self-contained course. For this reason, many aspects of the course have been indicated rather than fully described. The hope has been that student initiative, particularly through the form of individual papers, would close many of these gaps.

At the same time, it is essential to note that enormous areas of research have yet to be conquered in this field. For example, a relatively elementary problem such as an estimate of the specific effects of different types of assortative mating on initially random genetic pools has yet to be

ecological application is that of sedimentology whereby the work of [illegible] [illegible] shows the [illegible] effort of [illegible] [illegible] great success [illegible] [illegible] [illegible]

[illegible]

Recurrent [illegible] Analysis

Recurrent group analysis [illegible]

[illegible]

worked out satisfactorily. Again, almost nothing is known about the natural history of diseases in terms of their actual spread and the limits of their control by natural immunities or other blocks. Almost all we have recorded are chains of infection in acute stages. Moreover, the models we use are to a large extent based on the patently false concepts of random social and inter-species interactions. The Center for Zoonoses Research at the University of Illinois has begun, since late 1962, a long-term effort of careful accumulative observations which should, for a limited number of pathogens, provide some of the first rigorous epidemiological materials extant.

To conclude, work on human ecology is very actively expanding in a number of institutions, in the United States and abroad. To illustrate one important development: the University College, London, has been offering since 1960 a postgraduate course on resource management which comprises both thorough theoretical foundations and training in field work methods in the laboratory and on the ground. Subjects covered in this curriculum include physical geography, plant and animal ecology, land utilization theory, with particular emphasis on the cultural landscape, the major uses of land, and competition for land. Among its staff are botanists, geographers, zoologists, and engineers. Thus, our course in human ecology at Illinois represents only one part of a broadly awakening area of research and training.